DRAFT
AIR QUALITY MANAGEMENT PLAN
1988 REVISION

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APPENDIX IV—B
TIER III CONTROL STRATEGY: ENERGY FUTURE

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

JUNE 1988

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Chapter I Introduction

Application of conventional add-on control devices have not been able to sufficiently control emissions from fuel combustion processes. As a result, the District is considering large scale electrification as a more stringent alternative for further controlling fuel combustion emissions, especially for NO_x , and ROG in the case of motor vehicle emissions. However, the trade-offs between emissions from fuel combustion and power generation are a major concern. Therefore, this study is designed to examine the additional power generation required, the available energy alternatives, the emission reduction potential, and other impacts associated with such an electrification strategy.

Chapter II Study Approach

This chapter specifies the scope of study, assumptions used in assessing the energy demand of electrification and the associated emission reduction potential, the criteria used in selecting energy alternatives, and the study method.

Chapter III Fuel Combustion

This chapter identifies emissions from fuel combustions in residential, commercial, industrial, and commercial sectors. These emissions can potentially be reduced substantially by electrification. The 2007 emissions inventory for these secotors are projected to be 290 tons/day of ROG; 540 tons/day of NO_x; 3,700 tons/day of CO; 50 tons/day of SO_x; 100 tons/day of PM. By 2007, the transportation sector accounts for more than 90 percent of the total ROG, CO, and PM emissions, about 70 percent of NO_x emissions, and 65 percent of SO_x emissions. The industrial sector holds the second lead for all pollutants.

Emissions from existing power generating facilities (i.e., utilities, cogenerators), amount to about 56 tons/day of NO_x. These cannot be controlled by electrification. However, it is expected that emissions will be reduced by proposed Tier I control measures to 0.03 pounds per million btu heat input. New power plants or major modification of existing power plants will be subject to the revised New Source Review currently under development which requires that emission increases must be completely offset. Therefore, this study does not seek additional control for power plants.

Chapter IV Electrotechnology and Energy Demand

This chapter examines potential electrotechnologies to substitute fuel combustions, energy requirements, and estimated peak capacities. Electrification in the residential and commercial sectors involves the use of electric energy instead of fossil fuels (e.g., natural gas, fuel oil) for water and space heating purposes. Electric appliances for the residential sector are mostly off-the-shelf products. It is estimated that about 34,000 to 45,000 GWh/year of electricity (with a potential day-time peak capacity of between 8,000 and 11,800 MW) are needed to electrify the entire residential sector. Technology applied to the commercial sector for heating purposes would essentially be similar to that for the residential sector, but on a much larger scale. Approximately 29,000 to 46,000 GWh/year with a peak demand of 7,500 to 11,800 MW, are required to support electrification in the commercial sector. Supplemental technologies such as thermal energy storage, heat pumps, solar heating, and waste heat recovery should be aggressively pursued to reduce the demand for electric energy.

Fossil fuels are consumed in the industrial sector to provide process heat through a working fluid or to provide mechanical work. Many forms of electrotechnologies do exist which can potentially replace fossil energy and, at the same time, accomplish the desired operations. Examples include: direct arc melting, induction melting, electron beam heating and curing, infrared drying and curing, resistance heating and melting, microwave heating and drying, and radio frequency heating and drying. An assessment based on limited data indicates that about 4,400 GWh/year and 1,500 MW are needed to support industrial electrification.

Electrification in the transportation sector involves the conversion from petroleum-powered vehicles to those powered by electricity. These include automobiles, buses, and trains. Railroad and mass transit system electrification have been proposed as Tier I control measures Electric vehicles are expected to be phased in as a Tier II control. Assuming no VMT control in Tier I and Tier II, the total energy demand would be approximately 136,000 GWh/year. If battery charging for passenger vehicles is limited to week nights, and is the sole source for electric energy, a night-time peak of 45,400 MW is expected. The development of methanol/fuel cell electric vehicles and improvements in vehicle performance will reduce the energy demand as well as peak capacity needed.

Chapter V Energy Supply

Four major objectives are being pursued in planning the future Basin energy supply. They include: (1) maximum in-basin load management applications; (2) maximum out-of-basin power import, if fossil fuels are used to generate electricity; (3) maximum power output from existing power generating plants without adding additional emissions; (4) maximum waste heat recovery from must-burn combustion processes; and (5) promoting non-polluting power generating technologies.

Implementation of vehicle travel control and energy conservation measures as proposed in Tier I and Tier II can reduce electric energy demand significantly. Recent development of other load management technologies such as superconductors, heat pumps, and thermal energy storage provides a promising future that electricity demand due to electrification strategy could be further reduced. Currently, about 80 percent of Basin's demand for power is imported. It is extremely desirable that the same trend would continue to support the electrification strategy. This would probably be the case due to stringent New Source Review rules.

For future in-basin power generation, technical breakthroughs and commercialization of certain power generating technologies are needed. Examples include advanced combined cycles, fuel cells, and solar and wind turbines.

Chapter VI Strategic Plans

Three electrification plans are proposed in this chapter. Each plan represents a certain degree of penetration by electrification. Plan I includes full electrification in the industrial sector and partial electrification in the transportation sector. Plan II, to be implemented in addition to Plan I, requires full electrification in both the residential and commercial sectors. Plan III calls for electrifying the entire basin in all sectors. For each plan, the required energy demand, emission reduction potential, and control effectiveness, the amount of megawatts needed to remove every ton of pollutant, are identified. . A power supply matrix is also provided to illustrate the likelihood of power availability. The choice on how far electrification should go will be determined by the emission reduction needed to attain the federal and state air quality standards.

Chapter VII Economic Impacts

This chapter analyzes the economic impacts of substituting electricity for fossil fuels in the residential, commercial, industrial, and transportation sectors of the Basin. The analysis focuses on quantifying the additional energy costs resulting from 100% electrification of residential, commercial, and industrial fuel combustion processes; and from a 20% penetration in passenger vehicles, light- and medium-duty trucks. Estimates of market losses to the petroleum and natural gas industry are also provided.

The long-range economic impacts of electrification depend upon future economic conditions; the extent to which the additional electricity supply is imported; consumers' and producers' reaction to the plan; the future prices of energy alternatives; and technological changes affecting energy needs. Based upon the data presented, electrification may require about $4 billion of additional energy expenditure per year. These additional energy costs are likely to fall upon the residential and commercial sectors of the Basin. The petroleum and natural gas industries would also experience significant losses as a result of the strategy studied.

Chapter VIII Conclusions and Recommendations

This chapter summarizes findings discussed in previous chapters, and concludes that an electrification strategy, in principle, is a viable alternative to conventional air pollution control actions. The potential air quality benefit would depend upon the implementation of energy conservation measures, the availability of imported power, and the development of non-polluting energy technologies.

Electrification in the transportation sector provides the most emission reduction potential among all sector studied. Commercialization of electric vehicles, both battery-powered and methanol/fuel cell-powered, in the near future, is critical to the success of this strategy. Substantial public funding commitments to roadway systems and public acceptance of significant change in infrastructure are also needed.

Recent development in fuel cell power plants, superconductor power technologies, and various load management approaches appear to be promising alternatives to conventional fossil-fueled power generating technologies.

Assuming no emission trade-offs between fuel combustion and power generation, an electrification strategy could provide between 210 and 540 tons/day of NO_x, and 80 to 290 tons/day

of ROG reductions, depending on the extent of electrification.

Based upon the preliminary analysis presented in this study, recommendations to the District Board include: 1) performing more detailed evaluation on process-specific applications of electrotechnology; and on the economic costs and benefits of replacing fossil fuels with electricity, including the effects upon the Basin's employment, income, and health vasturbation; 2) participating aggressively in the development and commercialization of fuel cells, electric vehicles, energy storage technologies through the District Clean Fuel Program; 3) initiating dialogue with energy policy-making bodies to reflect specific local needs; 4) encouraging the power industry to take the lead in subsidizing and demonstrating new energy technologies, and disseminating information on these new approaches; and 5) seeking federal and state tax incentives to hasten the development of alternative energy options such as wind and solar power, fuel cells, and conservation measures.

CHAPTER I

INTRODUCTION

I.1 BACKGROUND

In order to attain the national and state air quality standards in an acceptable time frame, the South Coast Air Quality Management District (SCAQMD) has been constantly seeking effective air pollution control alternatives. Combustion of fossil fuels, traditionally used as a primary source of energy, constitutes a significant fraction of total stationary source emissions, principally nitrogen oxides (NO_x). Therefore, emissions from fuel combustion are targeted for further control. These emissions are now mainly controlled by the application of advanced combustion technology and/or sophisticated air pollution control equipment. Although these control measures have improved the air quality in the South Coast Air Basin, further reductions are needed to meet air quality standards. In addition, as new technology evolves, previously unavailable control options merit closer examination. Also, alternatives to technological applications must be considered. The current District Clean Fuels Program emphasizes combustion of fuels producing low emissions (e.g., natural gas, methanol) and electrification to reduce or eliminate emissions. This report considers electrifying fuel-burning processes in the residential, commercial, industrial, and transportation sectors to the extent technically feasible by the year 2007. In addition, this report also considers maximizing energy supply from out-of-basin sources and from emission-free, in-basin power generating units.

I.2 OBJECTIVES

The primary objective of this study is to identify the potential air quality benefits from large scale electrification. The key issue associated with electrification is the potential emission trade-offs between fuel combustion and electricity generation emissions. As a result, it is necessary prior to proposing basin-wide electrification as a means for air pollution control, to assess the additional electric power generation involved, the available electric energy alternatives, and other

impacts on the air basin as a whole. In order to resolve these issues, the following objectives are addressed:

To quantify potential in-basin electricity demand as a result of electrification based on known electrotechnologies and extent of penetration;

To identify environmentally acceptable in-basin power generating technologies and their potential air emissions;

To propose the strategic energy plans for the South Coast Air Basin;

To assess the emission reductions, control effectiveness, and economic impacts for the proposed strategy plans;

To recommend implementation activities and future research needs.

CHAPTER II

STUDY APPROACH

II.1 SCOPE

The scope of this study is basically governed by its objectives as outlined in the previous chapter. A more specific discussion on the study scope follows.

II.1.1 Time Frame

The evaluation of the electrification strategy is to comply with the ambient standards by the year 2007; therefore, a time frame of 20 years is used for assessing electricity demand and technology availability and readiness.

II.1.2 Electrotechnology

To completely study the substitute electrotechnologies for fuel combustion would require a detailed process-specific evaluation involving, at a minimum, analyses of existing equipment application, energy required for such application, facility physical configuration, physical form of energy required, technology availability, and energy economy. Based on such analyses, electrification feasibility and expected electricity demand could be determined. However, due to limited time and resources available for this study, electrotechnology is evaluated only on an industry-wide basis for generic categorical substitution. For example, microwave heating and drying is considered an acceptable substitute technology for food drying, defrosting, and cooking purposes in the food industry. Although specific process applications and product requirements might prevent such change, individual exceptions are not addressed. This study focuses on current or close-to-commercially available electrotechnologies, without extensively investigating those which might become available in the next 20 years.

II.1.3 Electricity Demand Forecast

The electricity required to support basin-wide electrification is assessed on the basis of projected levels of fuel combustion applications and the current knowledge of energy efficiencies for various electrotechnologies. Improvements in energy efficiencies are likely over the next 20 years, but they are not explicitly accounted for in the energy forecast. Therefore, the forecast is considered conservative with respect to future energy consumption. The

source categories to be impacted by the proposed electrification policy include the residential, commercial, industrial, and transportation sectors. Some electrification measures have been proposed in Tier I and Tier II, such as internal combustion (I/C) engines, transit buses, railroads, and electric vehicles. These measures are included again in this study to account for potential energy demand. The extent of electrification proposed for each sector is only bound by the technical considerations. In other words, cost is not a limiting factor for the purpose of this study (e.g., electrolytic separation, membrane processes). The use of electric energy not associated with replacing fuel combustion is excluded from this study. The additional baseline electricity demand by 2007 due to population and economic growth is likely to be met by the existing energy resources and the resources already committed to be available by then (SCE, 1987; CEC, 1986a). Therefore, this study does not address energy supply to meet the baseline demand; neither does it depend on those committed resources to meet electrification demand.

II.1.4 Energy Supply

For the purpose of in-basin energy planning and air quality evaluation, this study identifies new resources and additional capacities from existing uncommitted resources to supply electrification needs. Additionally, since a significant portion of the power demand in the District has traditionally been supplied by out-of-basin power sources, the study deals only with the portion of energy which must be generated in-basin.

II.1.5 Energy Resources

The evaluation of available energy resources is limited to those technologies that can potentially be installed within the Basin due to their local resource abundance and air quality merits. Technologies that may be acceptable for out-of-basin power generation but not applicable in the Basin are not included in this study. It is expected that the electric utilities will select energy alternatives based on economic factors and local regulatory requirements. For example, hydroelectric power plants and coal plants with integrated gasification combined cycles can have a significant role in the out-of-basin power supply matrix. However, limited local hydro and coal resources preclude them from becoming candidates of the in-basin power generating options.

II.2 ASSUMPTIONS

Major assumptions used in this study are as follows:

(1) There is no difference between year 2007 and year 2010 projection data (i.e., population, emission inventory). This is a conservative assumption since growth between 2007 and 2010 would increase emissions and electricity demand.

(2) The market share among the five utilities remains unchanged through 2007. These utilities are Southern California Edison (SCE), Los Angeles Department of Water and Power (LADWP), City of Burbank, City of Glendale, and City of Pasadena. The latter three utilities are considered together and referenced to as BGP.

(3) The fraction of system loss for in-basin power sources is negligible.

(4) System load factors are as follows: 0.54 is used for SCE (SCE, 1987). LADWP and BGP have a system factor of 0.48 and 0.45, respectively (CEC, 1987a; CEC, 1987b). (A system load factor is defined as the ratio of average capacity to peak capacity to account for coincidental electricity uses.)

(5) Reserve margins are as follows: 17.5 percent for SCE, and 22.4 percent for both LADWP and BGP are adopted to ensure supply reliability. (These factors are consistent with the figures used by California Energy Commission for the state-wide energy planning purpose) (CEC, 1986a).

(6) NO_x emissions from utility boilers and combustion turbines are to be limited to about 0.03 pounds per million Btu heat input as a result of two proposed rules currently under development (SCAQMD, 1987a; SCAQMD, 1987b; SCAQMD, 1988d). Therefore, any energy technology recommended in this study must be cleaner than that emission rate.

(7) The energy requirement and emission reduction potential due to electrification are estimated in the absence of Tier I and Tier II controls.

II.3 CRITERIA

In California, the state-wide energy policy and planning are established and coordinated through the California Energy Commission (CEC). However, for the purpose of air pollution control, the District seeks the maximum flexibility within the state policy guidelines in order to accommodate the local needs. The criteria used in formulating the District's energy strategy are summarized as follows:

(1) To assure energy resource diversity, no single energy resource should account for more than one-third of total demand as adopted by CEC (CEC, 1987c);

(2) To minimize potential emissions from in-basin electrical generation, any fossil fuel combustion is used to generate electricity will be located out of the Basin to the maximum extent feasible;

(3) To minimize the uncertainty inherent in energy forecasts and the risks in financial commitment, energy technologies with flexible size increments and short lead-times are to be emphasized;

(4) By the year 2007, electric generating technology qualified for installation within the District must have an NO_x emission factor less than, or at least equivalent to, 0.03 pounds per million Btu of heat input.

(5) Energy technologies with acceptable emission characteristics are not considered candidates for the future District power supply unless significant resources within the District exist. For example, hydro-electric power plants, wave energy plants, integrated coal gasification combined cycle plants, and compressed air energy storage plants will not play a significant role in the in-basin power supply matrix because preliminary analysis indicates limited resources available within the District (EPRI, 1986a; EPRI, 1986b; EPRI, 1986c; EPRI, 1987a).

II.4 METHODS

This section outlines the study method and steps taken to accomplish the objectives described in Section I.1.

(1) Identify major fuel-burning equipment permitted within the District and the associated emission

inventories. This will define the target equipment, processes, and the scope of problem.

(2) Identify available electrotechnologies capable of substituting fuel combustion.

(3) Assess the energy demand and peak capacity required by the year 2007 due to electrification based on findings from (1) and (2).

(4) Estimate the maximum out-of-basin power supply based on information provided by the utilities and historical demand/supply data.

(5) Define the in-basin power generation capacity needed to meet the demand by electrification.

(6) Identify candidate energy alternatives for in-basin power generation, and their potential capacities, if possible.

(7) Propose basin-wide energy strategic plans in relation to air pollution control based on findings (1) through (6).

(8) Recommend further study, research, and implementation activities.

CHAPTER III

FUEL COMBUSTION

Introduction

Modern civilization depends heavily on energy derived from fossil fuels. From household heating and cooking, day-to-day transportation, to heavy industrial product manufacturing, fossil fuels are consumed one way or the other to produce the necessary energy. Figures III-1 through III-4 show that fossil fuels play a significant role in the overall California energy use measured as heat input, ranging from 50 percent in the total commercial sector energy use to nearly 100 percent in the total transportation sector energy use. Although critical to the human society, fossil fuel consumption also constitutes a major air pollution problem, especially for NO_x emissions, and will be eventually exhausted. Expanding the use of electric energy could potentially eliminate the emissions from fossil fuel combustion, without jeopardizing living standards.

The following sections will discuss the emissions and the equipment or processes associated with fuel combustion within the Basin. From this, the extent of problem and the goal of emission reduction can be identified. Emissions from power generating facilities will also be addressed, and will serve as a baseline to determine if electrification will add additional emissions to the power plant source category, and at what levels.

III.1 EMISSIONS FROM FUEL COMBUSTION

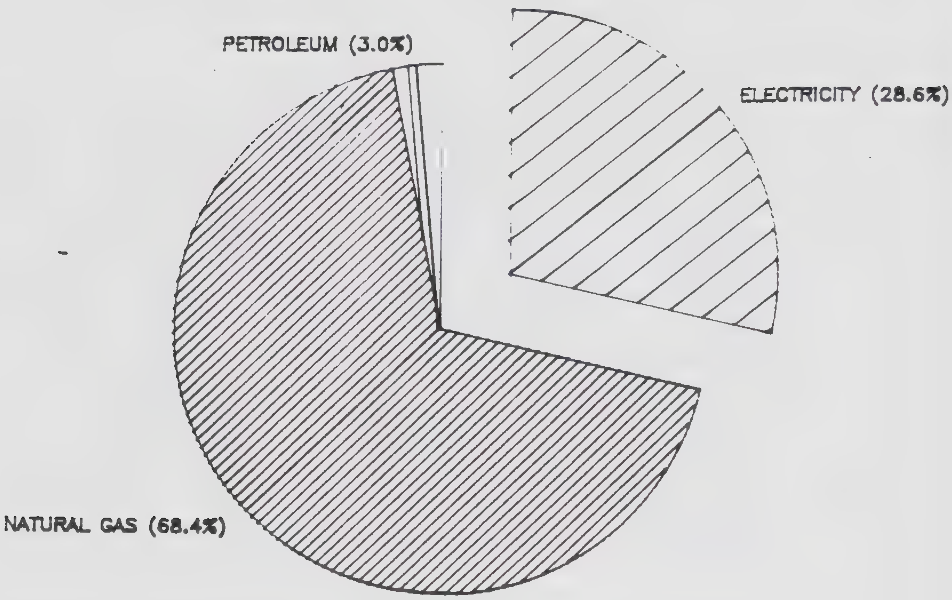
According to the 1985 emission inventory for the Basin, the emissions from all fuel combustion categories combined (excluding electric generating facilities) amount to about 790 tons/day of NO_x. These emissions are projected to decline to about 660 tons/day of NO_x by 2007. This reduction is due to assumed full implementation of several District rules and regulations by 2007. Tables III-1 and III-2 list the fuel combustion emissions for all pollutants by sector in the year 1985 and 2007, respectively.

III.1.1 Residential Sector

The main sources of emissions from residences are gas-fired water heaters, space heaters, and, to a lesser extent, cooking ranges and clothes dryers. It is estimated that there are about 3.3 million gas-fired water heaters and 1.6 million gas furnaces in the District (SCAQMD, 1988c). Emission inventories for this source category are presented in Tables III-3 and III-4 for 1985 and 2007, respectively.

FIGURE III-1 CALIFORNIA ENERGY USE

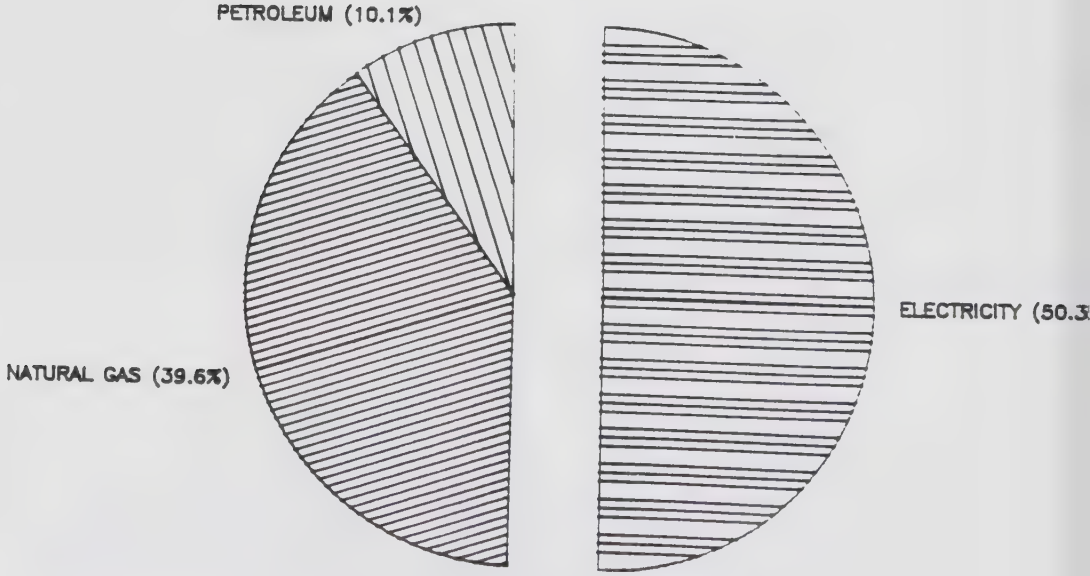
RESIDENTIAL END USE



Source: CEC. 1987. Fuels Report, Appendix A. p. A-2, November 1987.

FIGURE III-2 CALIFORNIA ENERGY USE

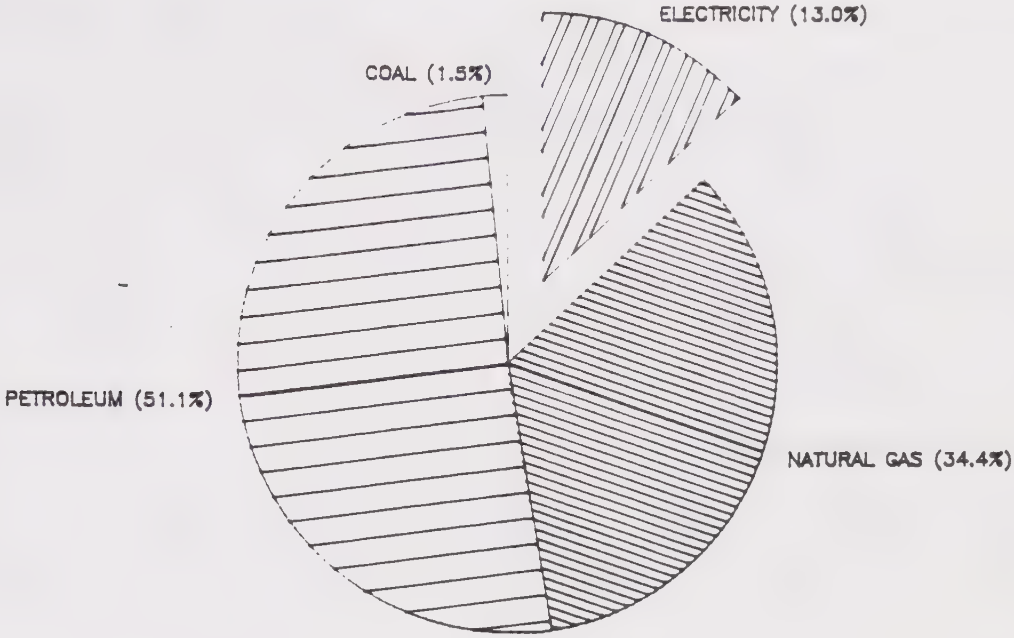
COMMERCIAL END USE



Source: CEC. 1987. Fuels Report, Appendix A. p. A-2, November 1987.

FIGURE III-3 CALIFORNIA ENERGY USE

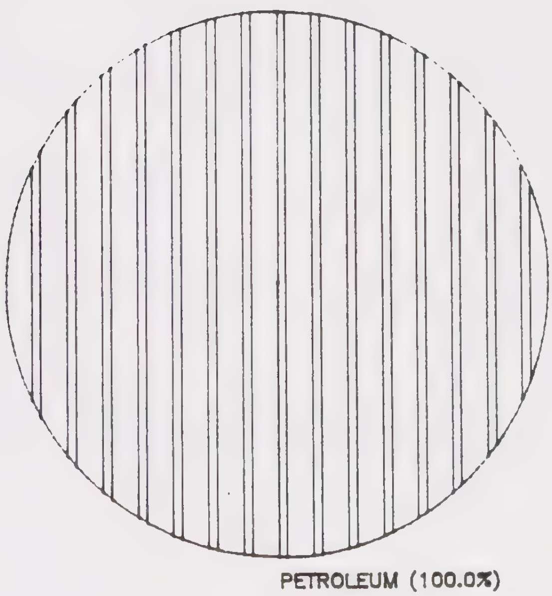
INDUSTRIAL END USE



Source: CEC. 1987. Fuels Report, Appendix A p. A-2, November 1987.

FIGURE III-4 CALIFORNIA ENERGY USE

TRANSPORTATION END USE



Source: CEC. 1987. Fuels Report, Appendix A. p. A-2, November 1987.

TABLE III-1
1985 EMISSIONS INVENTORY
FOR
FUEL COMBUSTION CATEGORY

SECTOR	POLLUTANT (TONS/DAY)(a)				
	ROG	NOx	CO	SOx	PM
RESIDENTIAL	1.3	30.4	12.1	0.8	1.7
COMMERCIAL	0.5	10.0	2.7	0.2	0.5
INDUSTRIAL	12.2	165.4	41.6	12.2	6.9
TRANSPORTATION	519.9	468.5	3994.6	23.9	60.7
TOTAL	533.9	674.3	4051.0	37.1	69.8

(a) values derived from the 1985 Emissions Inventory (Appendix III

TABLE III-2
2007 EMISSIONS INVENTORY
FOR
FUEL COMBUSTION CATEGORY

SECTOR	POLLUTANT (TONS/DAY)(a)				
	ROG	NOx	CO	SOx	PM
RESIDENTIAL	2.0	32.4	19.1	1.1	2.8
COMMERCIAL	0.8	19.9	5.4	0.3	1.0
INDUSTRIAL	16.8	105.4	66.1	15.7	7.5
TRANSPORTATION	273.0	384.7	3557.6	32.3	90.7
TOTAL	292.6	542.4	3648.2	49.4	102.0

(a) Values derived from the 2010 Baseline Emissions Forecast (Appendix III-B).

TABLE III-3
1985 EMISSIONS INVENTORY
FOR
RESIDENTIAL SECTOR

SOURCE	POLLUTANT (TONS/DAY)				
	ROG	NOx	CO	SOx	PM
WATER HEATERS	0.1	12.3	1.3	0.1	0.2
SPACE HEATERS	0.6	13.6	3.3	0.1	0.4
OTHERS	0.6	4.5	7.5	0.6	1.1
TOTAL	1.3	30.4	12.1	0.8	1.7

TABLE III-4
2007 EMISSIONS INVENTORY
FOR
RESIDENTIAL SECTOR

SOURCE	POLLUTANT (TONS/DAY)				
	ROG	NOx	CO	SOx	PM
WATER HEATERS	0.1	10.2	2.0	0.1	0.3
SPACE HEATERS	0.8	15.5	4.7	0.1	0.6
OTHERS	1.1	6.7	12.4	0.9	1.9
TOTAL	2.0	32.4	19.1	1.1	2.8

III.1.2 Commercial Sector

Emissions from the commercial sector defined in this study are limited to space heaters, water heaters, and other services(e.g., restaurants). This is due to the fact that the District emission inventory codes do not report commercial boilers and furnaces separately from those used in the industrial sector. Therefore, they are incorporated in the following industrial section. Emission inventories for the 1985 and 2007 commercial sector are shown in Tables III-5 and III-6.

III.1.3 Industrial Sector

Fuel energy is used in numerous industrial applications, primarily for process heating (i.e., steam, heated air) and producing mechanical work. The emission inventories for categories considered in this study are listed in Tables III-7 and III-8 for 1985 and 2007, respectively. The total District permitted units for each source category are provided in Tables III-9. As can be seen, there are over five thousand fuel-burning units perrmitted within the District, and more than 85 percent of them are smaller than 20 million Btu per hour of heat input.

III.1.4 Transportation Sector

Transportation vehicles are exclusively powered by petroleum fuels. The transportation electrification measures currently under consideration include light- and medium-duty vehicles, highways, transit buses, and railroads (see Appendices IV-A, IV-G). Therefore, only emissions from these categories are shown in Tables III-10 and III-11 for 1985 and 2007, respectively. Emissions inventory for the year 2007 shows a decline from the year 1985 due to full implementation of several adopted standards.

III.2 EMISSIONS FROM POWER GENERATING PLANTS

There are many oil and gas-fired utility power plants in the District. Most of them are older units, built in the 1950's and 1960's; they are operated as intermediate and peaking units to meet peak demand. Due to the passage of the Public Utility Regulatory Policies Act of 1978 (PURPA), several cogeneration projects, mostly under 50 mega-watts (MWs), have been proposed or built to maximize the system energy efficiency as well as to take advantage of mandatory electricity purchase by utilities at avoided costs. These cogeneration facilities are regulated by the District's New

TABLE III-5
1985 EMISSIONS INVENTORY
FOR
COMMERCIAL SECTOR

SOURCE	POLLUTANT (TONS/DAY)				
	ROG	NOx	CO	SOx	PM
WATER HEATERS	0.1	1.0	0.2	0.0	0.1
SPACE HEATERS	0.2	4.8	0.9	0.0	0.2
OTHERS	0.2	4.2	1.6	0.2	0.2
TOTAL	0.5	10.0	2.7	0.2	0.5

TABLE III-6
2007 EMISSIONS INVENTORY
FOR
COMMERCIAL SECTOR

SOURCE	POLLUTANT (TONS/DAY)				
	ROG	NOx	CO	SOx	PM
WATER HEATERS	0.2	2.1	0.4	0.0	0.1
SPACE HEATERS	0.3	9.1	1.8	0.1	0.5
OTHERS	0.3	8.7	3.2	0.2	0.4
TOTAL	0.8	19.9	5.4	0.3	1.0

TABLE III-7
1985 EMISSIONS INVENTORY
FOR
INDUSTRIAL SECTOR

SOURCE	POLLUTANT (TONS/DAY)				
	ROG	NOx	CO	SOx	PM
I/C ENGINES	7.8	81.7	36.1	0.6	0.6
BOILERS	1.6	31.3	1.3	4.6	2.9
GLASS FURNANCES	0.0	8.8	0.1	2.0	0.7
CEMENT KILNS	0.0	7.9	0.5	0.1	0.5
PROCESS HEATERS	1.2	18.5	0.9	2.2	1.8
OTHERS	1.6	17.2	2.7	2.7	0.4
TOTAL	12.2	165.4	41.6	12.2	6.9

TABLE III-8
2007 EMISSIONS INVENTORY
FOR
INDUSTRIAL SECTOR

SOURCE	POLLUTANT (TONS/DAY)				
	ROG	NOx	CO	SOx	PM
I/C ENGINES	8.8	30.3	43.3	0.7	0.7
BOILERS	1.6	26.1	1.4	4.4	2.1
GLASS FURNANCES	0.0	4.9	0.1	2.2	0.8
CEMENT KILNS	0.0	6.8	0.6	0.1	0.5
PROCESS HEATERS	1.2	11.6	0.9	1.6	1.8
OTHERS	2.3	30.9	2.4	4.8	1.8
TOTAL	13.9	110.6	48.7	13.8	7.7

TABLE III-9

SUMMARY OF MAJOR FUEL-BURNING EQUIPMENT

IN THE SCAQMD

EQUIPMENT	HEAT INPUT (MMBTU/HR)										TOTAL
	<0.15	0.15-<0.4	0.4-<0.65	0.65-<1.5	1.5-<5	5-<15	15-<50	50-<100	100-<200	>200	
COMMERCIAL/INDUSTRIAL BOILERS	0	0	0	0	380	651	454	92	21	14	1612
PROCESS HEATERS	94	0	0	2	24	51	70	30	3	1	275
METAL MELTING FURNANCES	171	108	66	170	161	52	39	0	1	7	775
GLASS MELTING FURNANCES	4	1	1	4	2	2	5	8	0	0	27
CEMENT KILNS	0	0	1	4	28	4	2	0	0	0	39
FOOD PROCESSING:											
SMOKE HOUSES	19	14	14	17	20	3	0	0	0	0	87
SMOKE GENERATOR	16	0	0	0	3	0	0	0	0	0	19
COOKING/CURING OVENS	6	3	5	1	2	1	0	0	0	0	18
BAKING OVENS	0	1	2	1	0	0	0	0	0	0	4
SUBTOTAL	41	18	21	19	25	4	0	0	0	0	128
DRYING/BAKING/CURING OVENS	704	476	387	402	309	65	8	0	0	0	2351
TOTAL	1014	603	476	601	929	829	578	130	25	22	5207

TABLE III-10
1985 EMISSIONS INVENTORY
FOR
TRANSPORTATION SECTOR

SOURCE	POLLUTANT (TONS/DAY)				
	ROG	NOx	CO	SOx	PM
PASSENGER CARS	398.5	327.8	3040.3	15.0	45.2
L&M-DUTY TRUCKS	113.7	106.3	937.7	5.4	11.8
BUSES	2.2	13.4	6.8	1.1	2.4
TRAINS	5.5	21.0	9.8	2.4	1.3
TOTAL	519.9	468.5	3994.6	23.9	60.7

TABLE III-11
2007 EMISSIONS INVENTORY
FOR
TRANSPORTATION SECTOR

SOURCE	POLLUTANT (TONS/DAY)				
	ROG	NOx	CO	SOx	PM
PASSENGER CARS	166.9	218.2	2149.0	16.5	64.4
L&M-DUTY TRUCKS	92.5	110.5	1379.4	10.3	22.0
BUSES	3.7	17.2	11.2	1.3	2.0
TRAINS	9.9	38.8	18.0	4.2	2.3
TOTAL	273.0	384.7	3557.6	32.3	90.7

Source Review Rules (Regulation XIII) that Best Available Control Technology (BACT) and offsets are required, if applicable. As a result, emissions from the cogeneration source category are relatively small. Tables III-12 and III-13 summarize the emissions from power generating facilities located in the Basin in 1985 and 2007, respectively. Table III-14 provides a list of individual utility oil and gas-fired power plants in the Basin, along with their generating capacities and year in service. As can be seen, these units total of about 11,100 MW of electric generating capacity within the air basin. Table III-15 summarizes cogeneration project generating capacity at various permitting, construction and operating stages. Cogeneration represents a total of about 1600 MW by 2007, assuming all projects under licensing review or are already permitted will materialize.

TABLE III-12
1985 EMISSIONS INVENTORY
FOR
POWER GENERATING UNITS

SOURCE	POLLUTANT (TONS/DAY)				
	ROG	NOx	CO	SOx	PM
UTILITIES	2.3	45.5	8.2	4.6	1.7
COGENERATORS	1.1	3.0	2.3	0.4	0.1
TOTAL	3.4	48.5	10.5	5.0	1.8

TABLE III-13
2007 EMISSIONS INVENTORY
FOR
POWER GENERATING UNITS

SOURCE	POLLUTANT (TONS/DAY)				
	ROG	NOx	CO	SOx	PM
UTILITIES	2.3	45.9	7.3	8.1	2.0
COGENERATORS	1.6	10.0	11.2	1.6	1.2
TOTAL	3.9	55.9	18.5	9.7	3.2

TABLE III-14
LIST OF UTILITY OIL/GAS CAPACITY
IN THE SCAQMD

UTILITY	STATION	CAPACITY (MWS)	IN-SERVICE DATE
SCE			
	ALAMITOS 1,2	350	1956-57
	3,4	640	1961-62
	5,6	960	1966
	7	133	1969
	EL SEGUNDO 1,2	350	1955-56
	3,4	670	1964-65
	REDONDO BEACH 1-4	292	1948-49
	5,6	350	1954,57
	7,8	960	1967
	LONG BEACH 8,9	530	1976-77
	HUNTINGTON BEACH 1,2	430	1958
	3,4	440	1961
	5	133	1969
	ETIWANDA 1,2	264	1953
	3,4	640	1963
	5	126	1969
	HIGHGROVE 1-4	154	1952-54
	SAN BERNADINO 1,2	126	1957-58
	SUBTOTAL	7548	
LADWP:			
	HARBOR 1	72	1943
	2-5	301	1947-49
	6-9	76	1972
	HAYNES 1-6	1570	1962-67
	SCATTERGOOD 1,2	358	1958-59
	VALLEY 1-4	517	1954-56
	SUBTOTAL	2894	
BGP:			
	BROADWAY 1,2	90	1955-57
	3	71	1965
	GRAYSON 3	21	1953
	4	47	1959
	5	49	1969
	6,7	53	1972
	8	98	1977
	MAGNOLIA 3	20	1949
	4	30	1953
	5	17	1969
	OLIVE 1	42	1959
	2	60	1964
	3	22	1972
	BURBANK	42	1984
	GLENARM 1,2	52	1975
	SUBTOTAL	714	
TOTAL		11156	

TABLE III-15
PROJECTED COGENERATION CAPACITY
IN SCAQMD BY 2007 (a)

PROJECT STATUS	CAPACITY
UNDER REVIEW	225
PERMITTED	860
CONSTRUCTING	210
OPERATING	300
TOTAL	1595

(a) Data derived from "Cogeneration Project Status Report," Engineering Division of SCAQMD. October 1987.

CHAPTER IV

ELECTROTECHNOLOGY AND ENERGY DEMAND

Introduction

Electrification of fuel combustion applications could be as simple as equipment substitution, or as complicated as manufacturing process modification. For instance, in the residential sector, electric water heaters or electric furnaces are off-the-shelf products and can be installed easily to replace gas fired units. However, to electrify an industrial boiler does not simply mean to install electric coils in the boiler to heat up the working fluid, and it may not be the best way to use the electric energy. Therefore, a process-specific evaluation on energy utilization would be required to identify the specific type of energy needed for a certain application, and what kind of electrotechnology can serve that purpose. One might find that application of modern electrotechnology could be more energy efficient than burning fossil fuels, and, at the same time, provide a more healthy and safe environment for workers (Moore, 1987; Cohen, 1987).

The following sections discuss candidate electrotechnologies for industry-wide electrification applications. Electric energy demand by 2007 due to electrification is estimated based upon the current knowledge of electrotechnology, fossil fuel consumption, fuel energy efficiency, and the number of permitted units within the District. These estimates are derived from data provided by SCE for the residential, commercial, and industrial sectors (Bazes, 1988). The uncertainties for the first two sectors are approximately plus or minus 20 to 30 percent. The data available for the industrial sector are limited and subject to greater uncertainties. Nevertheless, they provide "ball park" figures for the purpose of discussion. The estimates for the transportation sector are developed by District staff. The total energy needs are expressed in gigawatt-hours (GWh), representing actual electric consumption, whereas the peak capacity in megawatts (MW) takes into account the coincidence of power demand by consumers combined with reserve margins for system reliability.

IV.1 RESIDENTIAL ELECTRIFICATION

Current fossil fuel energy use in the residential sector is primarily for water heating and space heating, and to a lesser extent, cooking and clothes drying. Electric water heaters, furnaces, ranges, and dryers are readily available from local appliance stores at prices competitive to comparable gas appliances. However, interviews with a few retailers indicate that the sale of electric appliances is

substantially lower than for gas units. It is mainly because the cost of electric energy to operate the electric appliances is about two to three times higher than the cost of gas to run gas appliances. Furthermore, electric appliances are more difficult to repair if malfunctions occur (Sears, 1988; Montgomery Ward, 1988; Conitte, 1988; Spirit, 1988).

Based on projected fossil fuel consumption by 2007 in the residential sector, an expected gas appliance energy efficiency of 40 to 60 percent, and over 95 percent energy efficient for electric appliances, it is estimated that about 34,000 to 45,000 gigawatt-hours (GWh) per year of electricity with a potential day-time peak capacity of between 8,000 and 11,800 MW would be needed to electrify the entire residential sector. A basinwide system load factor and reserve margin are utilized in assessing the peak load, derived from individual utilities' system data (See Section II.2). This same approach was taken for all peak estimates in the following sections, where load requirements are expected to peak concurrently with the existing system demand curve. Solar heating and heat pump technology should be considered to reduce the electric energy demand in the residential sector. In fact, a control measure in Tier I has proposed to install solar collector on new and replacement water heating systems (see Appendix IV-A). Once implemented, 50 percent of residential water heating energy requirement can be reduced.

IV.2. COMMERCIAL ELECTRIFICATION

For commercial space heating and water heating, the electrotechnology is basically the same as that used in the residential sector. However, the energy output required from a commercial water heater or space heater unit would be significantly greater than for a residential unit. Therefore, application of supplemental technologies such as thermal energy storage, heat pump, waste heat recovery, and solar heating should be pursued to minimize the demand for electric energy. Other commercial fuel combustion equipment includes boilers, process heaters, and internal combustion engines. Since their applications are similar to those used in the industrial sector, the substituting electrotechnology is addressed in Section III.3.

Accounting only for the energy required for water heating, space heating, and other miscellaneous uses (e.g., restaurant cooking), and assuming similar equipment efficiencies as described in Section IV.1, electrification would require about 29,000 to 46,000 GWh per year with a peak demand of 7,500 to 11,800 MW.

IV.3 INDUSTRIAL ELECTRIFICATION

Fuel combustion equipment used for industrial applications includes various types of boilers, heaters, internal combustion engines, furnaces, kiln, and drying and curing ovens. A preliminary evaluation indicates that they serve two major purposes:

(1) To provide process heat through a working fluid (e.g., water, air) for melting, distilling, preheating, cooking, softening, drying, baking, fusing, and annealing of materials and products;

(2) To provide mechanical work for materials handling, materials processing, pumps, fans, and compressors.

Electrotechnologies for these same applications exist in many forms. Although design modifications or custom designs are expected for many operation-specific applications, they do not appear to present obstacles for conversion in terms of technical practicality. The concept of electrification emphasizes the use of electric energy to replace fuel combustion and, at the same time, accomplish the desired operations by the most effective electric technology. The following section discusses, on the basis of end-use applications, the major technologies available to replace the existing fuel-burning applications and are not all-inclusive (EPRI, 1986f; Moore, 1987).

(1) Electric Motors: The use of motors has its traditional role in a variety of industrial processes for prime movers, such as pumps, fans, and compressors; in connection with fluid processing; HVAC (heating,ventilating, and air conditioning) system. Motor drives can also control materials handling equipment, such as cranes, conveyors, and elevators. Motive force for operation of materials crushing, grinding or cutting can be provided by motors as well. The development of adjustable-speed drives (ASD) allows motors to operate at varied speeds to match varying load requirements. Such applications can significantly reduce the operating costs.

The District has recently permitted installation of four large electric motors (2000 HP) to replace four comparable internal combustion engines for rule compliance and potential emission offset credits. To electrify internal combustion engines involves not only the installation of electric motors, but also the motor starters, distribution system, and possibly substations and transformers (Mosher, 1988). Consultation with the Santa Barbara and San Luis Opisbo APCDs and private consultants indicates that electrification has been implemented for onshore internal combustion engines to comply with offset requirements, to mitigate environmental impacts, and to respond to public

concerns (Allen, 1988; Shafritz, 1988; Peirson, 1988; Lobnitic, 1988). The primary driving force for such conversion is air quality rule compliance and offset credits. To electrify non-utility internal combustion engines has been proposed as a Tier I control measure in the 1988 AQMP Revision (see Appendix IV-A).

(2) Heat Pumps: Heat pumps can be used to absorb heat and to elevate the temperature of this heat by compression for subsequent use. It is expected that heat pumps can be applied to fractional distillation in the petroleum and chemical industry. Heat pumps can also be used for optimization of heat use in space heating.

(3) Direct Arc Melting: In this application, material is loaded into an electric arc furnace and is melted by a direct arc. In this arc, the current passes from one electrode to another electrode through the metal charge. This type of electric furnace has commonly been used in the steel industry and is now used increasingly in foundries.

(4) Induction Melting: In this application, metal to be melted is placed inside of a coil where alternating current flows. The magnetic field-induced currents are able to melt metals. Two types of induction-melting furnaces are available: coreless and channel. Coreless furnaces are used primarily used for remelting and refining products. Channel furnaces are commonly served as holding furnaces.

(5) Plasma Processing: Plasma technology using high-intensity electric arcs is capable of achieving temperatures of 10,000^{o}F or more. As a result, it can change material physical and chemical status in a more efficient and economical manner. For purposes of comparison, the practical temperature limit for fossil fuel combustion is about 2800^{o}F. Although industrial application of plasma technology is still in its infancy, reliable torch hardware up to 5 MW is available, which is sufficient for most industrial applications.

(6) Electron Beam Heating and Curing: This technology uses a directed and focused beam of electrons to heat materials. Heat-treating with electron beams has been used in the metals industry and the automotive industry. Curing of wood finishing products and wire/coil coatings can also be accomplished by electron beams.

(7) Induction Heating: The primary application of induction heating is in the metal industry for material softening, heat treating, welding, and melting. The metal is placed inside of a coil through which

alternating electric current flows to produce heat within the workplace.

(8) Infrared Drying and Curing: Infrared radiation can be readily absorbed by many types of materials, such as textiles, wood products, paints, water, and some electronic components. Therefore, it has been used to dry water- and solvent-based surface coatings, to cure polymer coatings, to heat-set wrinkle-resistant synthetic fabrics, and to bond and laminate plastics.

(9) Resistance Heating and Melting: This technology uses electric current to produce heat, either directly through the material to be heated or through a heat-resistance heating element that transfers heat to the material by radiation and convection. These forms of electric heating have been used in the metal and glass industries.

(10) Microwave Heating and Drying: Microwaves are best used to heat and dry electrically non-conducting materials composed of polar molecules, such as water. The greatest application of microwave is in the food industry to preheat, cook, or dry the food products. Microwaves can also be used for rapid drying and curing of molds in foundries.

(11) Radio Frequency Heating and Drying: Applying the same principle as microwaves, electromagnetic radiation in the radio frequency range can be used to provide heat needed for certain industrial operations, such as the drying of paper, preheating of plastics, and the drying of glue in furniture and particle board.

Assuming the application of above-mentioned technologies, the total energy demand and peak capacity required by 2007 are 4,400 GWh per year and 1,500 MW, respectively. These numbers represent the lower end of the estimates for the industrial sector. This study does not cover every possible industrial application due to limited data available for evaluation. Table IV-1 provides a list of industrial equipment or processes considered in these energy estimates, and represents the majority of the Southern Californian business. It should be noted that modern electrotechnologies are efficient in terms of energy consumption, and there are not many energy-intensive industries in the Basin. Therefore, a complete analysis may show higher energy demand than what is presneted here; however, differences in an order of magnitude are not expected.

TABLE IV-1
LIST OF INDUSTRIAL EQUIPMENT/PROCESS
CONSIDERED IN ENERGY FORECAST

OIL PRODUCTION	GLASS MANUFACTURING
PETROLEUM REFINERY	DRYING &CURING OVENS
INTERNAL COMBUSTION ENGINES	COLD IRONING SHIPS
ALUMINUM FURNANCES	CHEMICAL PRODUCTS
FOUNDRIES	FOOD PRODUCTS
HEAT TREATING	TEXTILE MILL PRODUCTS
CEMENT KILNS	WOOD PRODUCTS
AEROSPACE INDUSTRY	PLASTIC & RUBBER PRODUCTS

IV.4 TRANSPORTATION ELECTRIFICATION

Currently the ARB, SCAG, and the District are developing various control measures to reduce transportation emissions. Several alternatives being examined include electric vehicles, electric highway and bus transit systems, and railroad electrification to replace conventional petroleum-fueled transportation vehicles. Control measures for electric vehicles, highway automation, and railroad electrification are described in Appendix IV-G of the 1988 AQMP Revision. The transit bus electrification is discussed in Appendix IV-A of the 1988 AQMP Revision.

Since the beginning of the automobile era there has been a niche for electric powered vehicles. Electric powered street cars and, later, electric buses, were common electric vehicle technologies. The lack of flexibility due to stationary power lines, usually located overhead, was the major drawback to these vehicles.

Battery powered vehicles also exist, however, battery powered vehicles have several problems. These include the range of distance, acceleration, maximum speed, and the life expectancy of the battery. These issues are still the basic problems confronting electric vehicle technology today.

Prototype and production design models of electric vehicles and associated technologies are becoming available for small scale testing and demonstration projects. General Motors, Ford, and Chrysler each have experimental electric vehicle programs. These companies are also manufacturing prototype vehicles, primarily vans, with the intent of developing production models.

The Electric Power Research Institute (EPRI) and Electric Vehicle Development Corporation have developed and tested several vehicles including GM's Griffon Van and the GM G-Van. Chrysler is currently developing the TEVan. The focus has been on commercial production of vans for institutional buyers. This is because these buyers (e.g., electric utilities and government agencies) use substantial numbers of these vehicles and offer a good test market for demonstrating EV technology. Another type of electric vehicle being developed uses fuel cells with methanol as the fuel. It has been estimated that a methanol/fuel cell/electric vehicle would emit 0.0016 gm/mile of HC, 0.00037 gm/mile of NO_x, and an undetectable amount of CO (< 100 ppm) compared to EPA emission standards of 0.41 gm/mile for HC, 2.0 gm/mile for NO_x and 3.4 gm/mile of CO (Romano, 1988).

Electric transit bus technology is used extensively outside of the United States. In the U.S., however, San Francisco has the most extensive electric bus system. Electrification of San Francisco's system using overhead tralley wires is expanding to cover 70% of the bus miles it operates by 1992. Advances in auxiliary power technology have increased the flexibility and reliability of electric transit bus systems. With intensive bus operation, electric buses are usually more cost-effective to operate in terms of per passenger mile than their diesel counterparts.

Power distribution systems and battery technology remain the two major problems in implementing large scale electric vehicle operations. Caltrans is currently beginning work in California on a project which will test the feasibility of operating vehicles on an electric guideway for long distances without relying solely on batteries. In Germany, similar research has been done on the use of magnetic induction to derive power from a track implanted in the roadway.

Research in battery technology for electric vehicles is progressing. Dependence upon lead-acid batteries for electric vehicles severely limits range and operating speed. Work is now in progress on a variety of new batteries. Sodium-sulfur, nickel-iron, nickel-cadmium, and lithium-sulfide batteries are all under testing or development. Most of these new batteries offer much greater range and higher speeds for electric vehicles.

The life expectancy of the battery presents a major obstacle to market penetration of EV's. Battery packs on the Griffon van cost over $8,000 and last approximately three years. This limits the economic acceptability of EV's. Research on battery packs is underway to extend their useful life and enhance their potential for recycling.

Presently, electric vehicles are using heavier DC motors. Lightweight AC motors are currently being tested for use in EV's. These motors offer the advantages of light weight, better power use, and faster acceleration. These motors will be operationally tested on the Chrysler TEVan.

The energy demands and peak capacities for each electrification strategy in the transportation sector are presented in Table IV-2, along with various degrees of penetration. As can be seen, electric vehicles consume far more electric energy than other proposed electrification components (i.e., buses, railroads). The estimate of peak capacity (reported in parentheses) for electric vehicles assumes battery charging to be limited to week nights, 50

TABLE IV-2
ESTIMATED ELECTRIC ENERGY AND CAPACITY REQUIRED
BY PENETRATION FOR
TRANSPORTATION SECTOR ELECTRIFICATION

CATEGORY	20 %		50 %		100 %	
	GWH/YR	MW	GWH/YR	MW	GWH/YR	MW
ELEC. VEHI.(a)	27000	(9100)	67000	(22700)	135000	(45400)
HIGHWAYS(b)(c)	[3900]	[2500]	[19000]	[5000]	[39000]	[10000]
BUSES(b)	16	4	78	20	155	40
RAILROADS(b)(d)	110	140	550	270	1095	540
TOTAL(a)	27126	144/ (9100)	67628	290/ (22700)	136250	580/ (45400)

(a) Values in () refer to nighttime peak loads, which include a 18% basin-wide reserve margin.
(b) A basin-wide system load factor of .52 and a 18% reserve margin are included in the estimates.
(c) Does not contribute to the total.
(d) Does not include potential savings from regenerative breaking. Railroad also have potential to avoid peak power demand.

weeks a year. Therefore, the peak capacity required for electric vehicles will be at night, different from the traditional peak demand to be during the day. The estimated energy demand and peak capacity for highway electrification (reported-in brackets) are based upon highway vehicle miles of travel in 1986. The use of electric highways can relieve some of the peak demand at night due to battery charging, but on the other hand, it will add to the daytime peak. Therefore, the energy estimates for highways are presented in Table IV-2 for informational purposes and are not included in the overall estimates for the transportation sector. The extent to which highways should be electrified would be determined based upon the best use of utility available capacity and the benefits to highway traffic improvement. The development of methanol/fuel cell electric vehicles can also reduce dependence on batteries, and consequently, reduce the night-time peak demand. The proposed vehicle travel controls in Tier I and Tier II could reduce travel miles in 2007 by about 40 percent to maintain at the 1985 levels. This would significantly reduce the electric energy required for electric vehicles. But, the electricity needs for transit buses would increase as a result of travel controls on individual vehicles.

IV.5 SUMMARY

Table IV-3 lists the total electric energy and peak capacity required for one hundred percent electrification by sector. As illustrated in Table IV-3, basin-wide electrification requires 241,820 to 270,420 GWh of electricity, with a peak capacity of 17,580 to 25,680 MW, in addition to existing demand. An another nighttime peak demand of 45,400 MW is also required for electric vehicle battery charge. The extent of penetration and the implementation schedule for electrification will determine how much and how soon this electric energy should be made available for electric conversion.

TABLE IV-3
SUMMARY OF ESTIMATED ELECTRIFICATION DEMAND
BY 2007 IN SCAQMD (100%)

SECTOR	ELECTRICITY			
	ENERGY(GWh/YR)		CAPACITY(MW)(a)	
RESIDENTIAL(b)	33800 ~	45200	8000 ~	11800
COMMERCIAL(b)	28800 ~	46000	7500 ~	11800
INDUSTRIAL	4370		1500	
TRANSPORTATION	136250		580 /(45400)(c)	
TOTAL	203220	231820	17580/ (45400) ~	25680/ (45400)

(a) A basin-wide system load factor of .52 and a 18% reserve margin are included in the estimates.
(b) Ranges reflect various equipment energy efficiences.
(c) Values in () refer to nighttime peak loads and only the reserve margin (18%) is included in the estimates.

CHAPTER V

ENERGY SUPPLY

Introduction

In order to maximize the air quality benefits of electrification, the trade-offs between fuel combustion emissions and power generation emissions should be minimized. Therefore, the following objectives must be pursued:

maximum out-of-basin power import if fossil fuel combustion is required to generate electricity for the Basin;

maximum power output from existing power generating plants without adding additional emissions (i.e., repowering with combined cycle);

maximum waste heat recovery from must-burn combustion processes (i.e., landfill gas);

promoting non-polluting power generating technologies (i.e., fuel cells, solar).

The following sections discuss the potential split between in-basin and out-of-basin power supply, and the in-basin energy technologies and their associated impacts.

V.1 OUT-OF-BASIN SUPPLY

An evaluation of the historic District power demand and supply data indicates that SCE and LADWP supply 74 and 23 percent of the total District power demand, respectively. The remaining 3 percent belongs to BGP. Due to the stringent emission limits and potential offsets required under the District Regulation XIII-New Source Review, utilities have been bringing in 70 to 80 percent of the total District power demand from out-of-basin sources (SCAQMD, 1986). The current in-basin to out-of-basin power supply ratios for SCE and BGP are 76 and 70 percent, respectively. LADWP receives about 80 percent of its power supply from outside of the Basin.

For the purpose of this energy analysis, LADWP and SCE were consulted on how much capacity can be brought in from out-of-basin sources. Both SCE and LADWP have indicated that their intention is to continue importing a significant portion of power capacity from out-of-basin sources.

Therefore, this report assumes that the Basin power import will maintain, at least, at a rate of 70 to 80 percent of the total utility power generating capacity. In fact, due to the stringent air quality requirements within the Basin, and abundant economical power supplies outside of the Basin, a higher import percentage is in the utilities' best interest, unless there are technical limitations. A high percentage of import power to the Basin should not jeopardize supply reliability because utilities will still directly own and operate most of the power generating facilities. Purchase of power supply outside of the utility systems in the range of 15 to 20 percent of the total utility generating requirements is generally considered reasonable (U.S. GAO, 1986). The abundance of hydroelectric energy from the Pacific Northwest and clean coal-fired plants in the Southwest due to rich coal deposits will contribute significantly to utility out-of-basin supply (CEC, 1986a).

V.2 IN-BASIN SUPPLY

Siting a power plant within the Basin has the advantage of being close to the end-users so that system transmission losses can be minimized. This section discusses two categories of energy technologies: 1) generating technologies that are preferred from an air quality perspective and are most likely to be permitted by the District in the future, and 2) load management technologies that do not generate electricity by themselves, but can conserve or store energy to reduce peak load requirements. The selection of certain energy technologies will largely be determined by utilities or small power producers (i.e., self-generators or cogenerators), based on evaluation of energy economies.

V.2.1 Power Generating Technologies

V.2.1.1 Advanced Combined Cycle

Technology Status: A combined cycle unit consists of a combustion turbine combined with a steam turbine to generate electricity. Exhaust heat energy from gas turbine is recovered to improve generation efficiencies. This efficiency is reflected in the system heat rate in terms of Btu per Kwh. The lower the heat rate, the more power output will be produced for the same amount of fuel burned. The conventional simple cycle system using a combustion turbine or a steam generator has a heat rate about 10,000 to 11,000 Btu per Kwh (Johnson, 1988; Wilcox, Jr., 1988). Application of current combined cycle technology will lower the heat

rate to about 8000 to 9000 Btu per Kwh. Recent combined cycle development using a GE MS7001F gas turbine has a heat rate of 6820 Btu per Kwh with an overall system efficiency near 50 percent. It is designed to have power output in excess of 200 MW (Tomlinson et al., 1987; GE, 1987). A recent installation in South Carolina for the Virginia Electric and Power Company is undergoing load testing and has demonstrated better performance than its design specifications. This facility is expected to come on-line in 1989 (Erwin, 1988). There are additional advanced combined-cycle facilities currently under development which will have about the same heat rate but at a scale of 600 MW per unit. These are expected to be commercially available by about 1990 (EPRI, 1986e).

<u>Potential Applications</u>: The above-mentioned advanced combined-cycle equipment can be applied to the following four categories:

(1) <u>Existing utility oil and gas units</u>: As listed in Table III-14, all the utility oil and gas units, except for one BGP unit, will exceed their 30-year service life by 2007. If power supplies from out-of-basin or emission-free sources are not adequate, the application of advanced combined cycle technology by life extension or repowering of the existing units can either reduce 30 percent of emissions for all pollutants, or increase 60 percent of power output (approximately 6700 MW) without emitting additional pollutants. It should be noted that there are two proposed rules being developed to control NO_x emissions from utility boilers and gas turbines by about 70 to 80 percent. This study assumes these rules will be implemented by 2007 and a lower system heat rate can provide futher emission reductions beyond the proposed rules.

(2) <u>Landfill gas flaring systems</u>: It is estimated that by 2007 there will be 23 to 43 millions Btu of landfill gas generated per year from solid waste disposal. The current District Rule 1150.1 requires that landfill gas be collected. Most of the facilities combust the gas in flares at high temperatures for hydrocarbon destruction. A few sell or use the collected gas as a fuel gas and some recover the waste heat for power generation. Since the electrification strategy would eliminate fuel combustion, the market for the sale of landfill gas would diminish except used as feedstock to fuel cell units (see Section V.2.1.2). In order to comply with Rule 1150.1,

combustion would probably be the only solution. As a result, it is proposed that landfill gas combustion system be tied to a combined cycles so that waste heat can be used for power generation. Since the advanced combined cycle units are designed at a utility scale (above 200 MW), their economic value or readiness in a timely manner for small scale applications such as landfill gas units are not certain. However, even based on the current combined cycle performance, an additional 300 to 500 MW can be added to the in-basin power supply. Flue gas treatment technologies (i.e., SCR, urea injection) to achieve at least 50 percent of NO_x emission reductions could be included to reduce even baseline emissions.
It should be noted that biodegradable solid wastes were proposed to be disposed of out of the Basin in Tier I. Once implemented, there would be negligible amount of landfill gas to be recovered by the year 2007.

(3) Cogeneration units: By 2007 fuel cell units are likely to be the preferred cogeneration technology (See Section V.1.1.2). However, some cogeneration units will still be in their 30-year service life by 2007 or will have been permitted prior to adoption of the electrification stratedy; therefore, the shift in technology can be economically prohibitory. The use of combined cycle as a retrofit technology can increase system efficiency and power output without adding more emissions.

In the above, the emphasis is to maximize the power output for every fuel that must be burned and to minimize the emissions per unit of power output.

Environmental Impacts: The decrease in the system heat rate will result in fuel savings, which, in turn, results in lower emissions. It is estimated that the GE advanced combined-cycle could potentially reduce NOx emissions by about 30 percent. The GE system has reported NOx emissions of 75 ppm (dry volume @ 15 percent O_2) achievable with water or steam injection. Flue gas treatment (e.g., SCR, CO catalyst) or burning methanol will still be required to meet the current District's BACT requirements.

Combined cycle technology is not expected to have additional water or solid waste impacts other than those already recognized for conventional units.

Economic Analysis: The capital cost to build a base-load advanced combined cycle plant is estimated to be about $1,200 to $1,400 per KW (1984 $), and the cost of the electricity produced is approximately 4.7 to 5.1 cents per Kwh (EPRI, 1986e). There could be a 3 to 6 percent cost saving from a repowered unit due to savings from initial capital investment (CEC, 1987d).

Barriers: The current excess capacity limits equipment orders by large electric utilities. This eliminates much of the market incentive for R&D companies to commercialize and refine the advanced systems. A clear District strategy on electrification could stimulate equipment manufacturers to bring about efficient and reliable systems to meet the future need.

Legislative Needs: In order to meet the District air quality regulations, the advanced combined cycle facilities must burn natural gas or methanol. The Powerplant and Industrial Fuel Use Act of 1978 prohibits power plants from relying on natural gas as the primary fuel. If the feedstock for manufacturing methanol is to be natural gas, then methanol would probably also be regulated under the Act, although it is not explicitly addressed in the Act. The Act provides exemptions for individual power plant owners for site-specific needs as long as use of alternative fuels (e.g., coal, solar) is not technically and structurally precluded. If it were District strategy to use natural gas-based fuels, then coordination among the Economic Regulatory Commission of U. S. Department of Energy, the California Energy Commission, and the District might be necessary in order to simplify the permitting process by obtaining a region-wide exemption.

Research Needs: In order to commercialize advanced combined cycle technology, several research activities are needed, including continuous optimization of gas turbine efficiency and reliability, which can lower the electricity costs. The development of high-temperature materials and equipment fabrication techniques could also aid the system performance and overall costs.

V.2.1.2 Fuel Cells

A fuel cell is an electrochemical device that converts the chemical energy of a fuel and an oxidant into electrical energy. The fuel cell in some ways resembles a flashlight or car battery with an anode and a cathode separated by an electrolyte. However there is an essential difference between a battery and a fuel cell. The car battery stores a

fixed amount of energy. A fuel cell produces electrical energy as the result of combining a hydrogen containing fuel and an oxidizer such as air. Thus the fuel cell doesn't run down or need recharging. It continues to produce power as long as hydrogen is supplied to the anode and oxygen is supplied to the cathode. Fuel cells combine hydrogen and oxygen to produce electricity, heat, and water, with virtually no emission of pollutants.

The fuel cell can use liquid or gaseous hydrogen containing fuels such as hydrogen, natural gas, synthetic natural gas, gasoline, diesel fuel, or methanol. Fuel cells can attain efficiencies of as high as 40-55 percent for electric power generation (Romano, 1988) and up to 80 percent in cogeneration applications (Department of Energy, 1987).

Technology Status: There are several different types of fuel cells which may be used to efficiently provide electrical energy with minimal environmental impact. Of the various fuel cells which have been developed, the following hold the greatest promise for application in the Basin during the next five to twenty years.

Phosphoric Acid Fuel Cells (PAFC)

In this type of fuel cell the electrolyte is phosphoric acid which separates flat plate anode and cathode. The fuel and oxygen bearing compounds are fed into the cell next to the electrodes which separate the fuel and oxidizer from the electrolyte. The PAFC has been in use for many years with power outputs ranging from about 5kw up to 40kw. Hundreds of these units have been used in R&D and demonstration projects. The 40KW unit has been used in many types of applications providing power and heat to small scientific, commercial, office, residential, and light industrial facilities. These units are normally fueled with natural gas but may also use naptha or methanol and operate at a temperature of about 212°F.

The 40KW units were designed mainly to be used in demonstration projects to prove the concept. One successful 40KW demonstration was conducted locally by Southern California Edison (SCE) at the Sheraton Hotel complex in Industry Hills (Free, 1986). The methane fuel was obtained from a capped landfill which had been covered by a golf course. The power from the fuel cell was used to provide electricity to the hotel and convention facilities. The heat from the fuel cell was used directly by the hotel and also to heat water for hotel use.

Now that the 40KW fuel cell power plants have been proven in use, the manufacturers are scaling the design up to 200KW. The 200KW size will be available shortly and used in the

same type of applications as the 40KW but will be more cost effective and efficient. The 200KW unit may become the standard size of small fuel cell power plant within the next five years.

Over the past 10 years, developmental work on PAFC power plants in the large 1MW-11MW size range has progressed. Several 1MW units are in operation in Japan where a 4.5MW demonstration plant manufactured in the U.S. was successfully operated in the middle 1980's (EPRI, 1984a). The same type of 4.5MW plant was constructed in New York in 1978 but never operated due to a long delay in obtaining the required operating permits which led to a separation of the electrolyte from the electrodes. The 4.5MW unit tested in Japan benefitted from newly designed cells and rapid permitting process.

The manufacturer of the 4.5MW plant has scaled up the design to 11MW and included improvements based on the New York and Japanese tests of the 4.5MW unit. The 11MW plants are currently being marketed in the United States and Japan. The manufacturer has stated that the time from order to startup would be about two years (International Fuel Cells, 1986).

Ceramic/Solid Oxide Fuel Cells (SOFC)

Solid oxide fuel cells uses solid oxides/ceramics such as strontium-doped lanthanum manganite, yttria-stabilized zirconia, magnesium-doped lanthanum chromite, cobalt or nickel stabilized with zirconia, and other ceramic materials for the electrodes and electrolyte. The SOFC uses gaseous hydrogen bearing fuel and air or other oxidizer as do phosphoric acid fuel cells but operates at a much higher temperature of about 1800°F. The SOFC generates enough heat to be used for bottoming cycles and for internal reforming of the hydrogen containing fuel. This is an advantage over the PAFC which needs an external reformer to extract the hydrogen. The greatest advantage of the SOFC however is it's simplicity. Since SOFC is a solid state device it should pose virtually no maintenance problems.

The SOFC does have some disadvantages because the materials used in the cell need to remain stable at the high operating temperature but must also have closely matched thermal expansion coefficients to prevent delamination of the ceramic layers. Also, because the individual cells are so small, the size of a small flashlight, unit power output is small. The largest SOFC power generation in use so far is about 5KW. Thousands of these cells would need to be wired together to approach the 1MW - 4.5MW output already demonstrated by phosphoric acid fuel cells. Commercial use

of these larger size SOFC's are at least 5 to 15 years in the future.

Molten Carbonate Fuel Cells (MCFC)
The previously discussed fuel cells, PAFC and SOFC, have the potential for use as dispersed power sources and perhaps in transportation vehicles. However, for use as a replacement for base load utility power plants, the molten carbonate fuel cell appears to have the most promise for application 10 to 20 years hence. The use of molten carbonate (salt) fuel cells for use in power plants up to 675MW is currently under investigation (Jet Propulsion Laboratory, 1986). Several proposed plants of this type have been designed and their operating characteristics specified.

The MCFC has a number of advantages over the PAFC. The MCFC operates at a working temperature of about 1300^{o}F. At this temperature no catalysts are needed to speed up the chemical reactions which produce the electric power. A platinum catalyst is used in the PAFC to speed up the reaction but would not be needed in the MCFC. Since platinum is quite expensive, avoiding it's use would decrease the installed cost of power plants based on MCFC. The molten carbonate fuel cell is also more efficient than the PAFC, 55 percent verses 40 percent. In addition, the hot steam generated by the MCFC could be used to generate more electricity in a turbine bottoming cycle.

Another possibility is to use the waste steam from the MCFC to convert a hydrocarbon fuel into the needed hydrogen within the fuel cell itself. This is called internal reforming and its use would significantly reduce the capital cost of a fuel cell power plant. One of the most closely studied MCFC power plant designs uses synthetic natural gas produced in an adjacent coal gasification plant as the fuel. The MCFC offers promise for use as a medium size (up to 100 MW) or base load (up to 1000 MW) power plant but the technology will not be thoroughly tested for 10 to 15 years and may not be ready for commercialization for 10 to 20 years.

Potential Applications: Potential applications range from using a 40 KW PAFC to power small facilities up to using MCFCs to power a 1000 MW baseload utility power plant. The smaller PAFCs in the range 40 KW - 1000 kw are now being used for commercial, residential, and light industrial facilities. These small fuel cell units, either PAFC or SOFC, may also be used to power automobiles, light trucks and buses (Romano, 1988). The Department of Energy is funding two contractors to design and build small electric buses using a methanol fueled PAFC (Business Week, 1987). The result of this project may be a small experimental fleet

of methanol fuel cell electric buses. Researchers at Argonne National Laboratory are developing a concept in which small ceramic SOFCs are used to power an electric automobile (Business Week, 1986; Ashley, 1987).

Dispersed fuel cell power plants can be used as cogeneration power plants to provide electricity and heat to small complexes including shopping, office, and commercial facilities as well as apartments. Because these units can be expanded easily by using extra power modules, there are many potential uses in an urban area such as the South Coast Air Basin.

The large baseload molten carbonate power plants could be used to replace the large fossil fueled combustion utility plants as they reach the end of their useful life. PAFCs can be used now for utility peaking applications to replace fossil fueled combustion turbines.

Environmental Impacts: Compared to most other sources of electric power generation, the fuel cell power plant is environmentally benign. Fuel cells combine hydrogen and oxygen to make electricity, water, and heat. The operation is virtually soundless and no solid waste is produced. Emissions of air pollutants are very low for PAFC's and lower for other types of fuel cells which use internal reforming of the hydrocarbon fuel.

Emissions from the 11 MW PAFC power plant now being marketed are expected to be about 6 lb/day of NO_x (0.003 lb/MMBtu), 0.1 lb/day of SO_x, 7.5 lb/day of particulate matter and virtually no ROG emissions (Smith, 1986). These emissions result primarily from the external reforming process necessary to produce the hydrogen used as fuel. Newer units are expected to have lower emissions. NO_x emissions of MCFC plants are estimated to be about 1 ppm compared to 5 ppm for PAFCs and 20 ppm for combined cycle plants (EPRI, 1987b).

Economic Analysis: The installed cost for the first 11 MW PAFC power plants will be about \$2500-\$3000/KW (Raia, 1984), which is much higher than the \$700-\$900/KW of a modern steam boiler or combined cycle power plant. However the cost would be expected to decrease to the \$1000-\$1200/KW range as more PAFC fuel cell plants are built (CEC, 1987d). The California Energy Commission (CEC) has estimated that the electricity produced would cost about 7.0 to 8.8 cents/KWh (CEC, 1987d). It has been estimated that PAFC plants could be mass produced for as little as \$350/KW if the production rate were about 500 MW per year (Raia, 1984).

The smaller natural gas PAFC units in the 40 KW to 400 KW capacity should be able to produce electricity for an installed cost of $850 to $1250/KW (Raia, 1984).

It has been estimated that the capital requirements for the larger (100 - 700 MW) molten carbonate systems would be in the $1800 - $1900/KW range (EPRI, 1986e). The same EPRI report estimates the installed cost for a combined SOFC gas turbine/steam turbine power plant in the 700 MW range to be about $1400/KW.

Barriers: The relatively high installed cost and the present surplus of electric power generating capacity are currently the greatest barriers to market penetration of the 40 KW to 11 MW phosphoric acid fuel cell power plants. The solid oxide and molten carbonate systems are 5 to 15 years behind the PAFC systems and their introduction will also be hindered by high initial capital costs. As market acceptance is achieved by these three types of systems, the installed costs should drop significantly.

There are also technical problems which must be solved to reduce the costs and to speed development of the more advanced systems such as the SOFC and MCFC. Examples of technical problems needing solutions are: the requirement for replacements for platinum catalysts used in PAFC power plants; material compatibility and durability problems; polarization losses resulting in lower practical operating voltages; operations at higher temperatures or pressures at which increase the operating voltages but where the materials and hardware problems are exacerbated.

Legislative Needs: There does not appear to be any serious legislative barriers at present to widespread use of fuel cells. However legislation at state and federal levels is needed to increase government funding for demonstration projects for advanced systems should be introduced.

Research Needs: Additional research is needed to develop substitute materials, such as less expensive catalysts for PAFC's, and more durable materials. Contamination of the fuel cell electrodes and electrolyte must be reduced. Conceptual design and trade-off studies to establish performance and cost goals for components must be performed. Continued research to improve components performance and reduce cost is needed. Additional research is needed to reduce production and installation costs. More research is needed to settle on the most appropriate ways to produce the hydrogen bearing fuel used in the more advanced systems. Other problems must be solved before a mobile fuel cell/electric vehicle becomes viable, such as the high cost,

size and weight of present systems, and the mobility of an operating fuel cell. Research to solve the cathode stability problems in MCFCs is needed. Corrosion problems need to be solved.

In conclusion there does not appear to be any insurmountable or basic technical barrier to widespread use of fuel cell power generation during the next 20 years.

V.1.1.3 Solar

Technology Status: There are several different types of technologies used to capture the sun's energy and generate electricity.

Photovoltaic Cells

Photovoltaic cells are used to convert solar radiation directly into electricity. When photons from sunlight strike the cell, electrons are knocked free from the atoms of the cell and are drawn off by a grid of metal conductors, yielding a flow of direct current. Solar cells offer several advantages over conventional sources of electricity. They require no fuel, are self-contained, have no moving parts, emit no pollutants in operation, need little maintenance, and have a lifetime of over 20 years. Groups of photovoltaic cells can be mounted onto a rigid plate and wired together to form modules which become the building blocks of solar electric systems.

A typical silicon solar cell module has a surface area of half a square meter and a generating capacity of about 50 watts. The power output of a photovoltaic system is rated in kilowatts of peak power, i.e., the wattage the cells would deliver when exposed to vertical rays of noon sunlight on a clear day. Virtually any power output can be supplied by mounting a number of module into panels which can in turn be combined into large arrays. The total power produced by a given array is of course dependent upon it's location and the peak altitude of the sun.

At present the most promising types of photovoltaic cells for power generation are crystalline silicon, thin film amorphous silicon, and gallium arsenide. The maximum efficiencies which have been attained to date with flat plate crystalline silicon cells are in the 11 to 14 percent range (Tucker, 1984; EPRI, 1985a). Thin film amorphorous silicon solar cells have reached efficiencies of 14 percent (Business Week, 1988). Some of the highest solar cell efficiencies yet obtained in the lab have been realized with a relatively new solar cell material, gallium arsenide.

Gallium arsenide cells have achieved efficiencies of 22.4 percent (Business Week, 1988) and 25 percent (EPRI, 1985a).

Solar Central Receiver

A solar central receiver is composed of a series of mirrored panels (heliostats) which reflect the sun's rays onto a tower-mounted central receiver. (EPRI, 1983b) The receiver contains a boiler through which superheated steam is generated to produce electricity.

A solar central receiver is currently used at the world's largest solar electric generating station, Solar One. It is a joint project of Southern California Edison, the L.A. Department of Water and Power, the California energy Commission, and the U.S. Department of Energy. Located on 130 acres in the Mojave Desert east of Barstow, California, Solar One is a 10 MW plant which began producing electricity in 1982 with a system efficiency ranging between 11 and 13.5 percent (EPRI, 1983b).

Parabolic Concentrating Collectors

Parabolic dishes and parabolic troughs are the two primary types of parabolic concentrating collectors. Mirrored parabolic solar dishes are modular units which reflect sunlight and concentrate it onto a raised receiver attached to the unit. Typically, the disks track the sun to maximize the amount of energy concentrated on the receiver. A circulating gas (usually hydrogen or helium) is heated as it flows through the unit. The gas in turn is used to power a piston-driven Stirling engine to generate electricity (EPRI, 1986g).

Solar dishes have been used in Rancho Mirage, California as part of a demonstration project sponsored partially by Southern California Edison. Each dish can produce approximately 25 kW of power (EPRI, 1986g). Due to the modular nature of the dishes, they can be grouped together to pool their electrical generating capacity. In this project, the net efficiency during daylight hours ranged between 16 to 26 percent (EPRI, 1986g).

Solar troughs use a mirrored parabolic surface to concentrate the sun's rays onto a tube through which a liquid flows. This liquid could be water or a liquid metal such as sodium which flows through a heat exchanger to generate steam to power a turbine (Krenz, 1980). The troughs can be stationary, or either the mirrors or the collector can move to maximize the amount of energy collected from the sun.

Solar Salt Pond

Solar ponds are natural or artificial lakes in which a strong salinity gradient (halocline) is present. The dense brine located at the bottom of the pond absorbs and stores solar energy. The halocline prevents mixing between water strata within the pond, with temperatures at the bottom layer exceeding 30 degrees Celsius (EPRI, 1985c). The energy stored in the lower layers of the pond is then extracted by using a heat exchanger or by pumping the heated brine from one end of the lower layer and reintroducing it at the other end after the heat has been extracted from an external heat exchanger.

In Israel, several salt ponds have been devloped to generate electricity, providing between 6 kW to 5 MW of electricity (EPRI, 1985c). Solar ponds have also been built in Ohio to heat a local municipality's swimming pool and recreational hall and in Tennesee as a design prototype. Southern California Edison has also entered in to a joint venture with Israel's ORMAT to develop four 12 MW solar ponds at Danby Lake in the Mojave Desert (EPRI, 1985c).

Potential Applications: Solar electrical power generation requires both a continuouslly available source of direct sunlight and the availablity of sufficient land to site the concentrating and collecting devices. The climate in Southern California is conducive to the use of solar systems because of the reliability of direct sunlight. Substantial desert land that meets these criteria is still available in Southern California.

Other technologies such as parabolic dishes and solar heating and cooling systems are more amenable to use at smaller sites.

Environmental Impacts: Solar technologies produce little air pollution. Solar concentrator and receiver technologies produce a bright glare when in operation that may be disturbing to both humans and wildlife. Siting considerations can help mitigate this impact.

The potential for substantial environmental impacts from the use of solar salt ponds exists. Groundwater and surface water contamination from the brine and chemical pond additives, as well as disturbances to the surrounding land and surface waters from construction, are concerns (EPRI, 1985c). However, many of these impacts can be mitigated through careful evaluation of the pond site and through the use of suitable materials to line the pond to minimize the potential for brine leakage.

Economic Analysis: Investment in solar systems was encouraged through the availability of federal and California state tax credits (EPRI, 1983a). However, these tax credits will be completly phased out in 1988 if no further legislative changes are made.

Electricity generated by solar central receiver technology is expected to cost between 4.3 to 6.9 cents/kWh (1988 dollars) (CEC, 1987d). The cost of parabolic dish technology ranges between 6.9 to 13.1 cents/kWh (1988 dollars) (CEC, 1987d).

Barriers: The efficiency of solar electrical systems may be a limiting factor for significant proliferation of solar technologies. Large numbers of concentrators are needed to focus the sun's rays onto a receiving device. The efficiency of these systems can be impacted substantially by the cleanliness of the mirrored reflectors and the medium used to power the electrical generating systems.

Land availability, land use preference, and environmental concerns can potentially make siting solar power plant difficult.

Legislative Needs: Legislation may be required to reintroduce tax credits to make solar powered projects more attractive to investors. Tax credits available in the past have helped spur interest in developing alternative technologies such as solar power.

Research Needs: The efficiency of solar technolgies needs to be addressed through continued research and development. Improved heat transfer and storage systems as well as innovations in steam turbine technologies could impact the viability of solar power as an energy source.

V.2.1.4 Wind

Technology Status: Wind-driven turbines generate electricity by harnessing air currents. Approximately 98 percent of the 1,134MW of electricity generated by wind turbines in the U.S. is produced by over 13,300 wind turbines located in California (EPRI, 1987c).

Horizontal-axis and vertical-axis turbines are the two most common types of wind turbines. Horizontal-axis turbines rotate parallel to the wind direction. Exemplified by the traditional Dutch windmill, horizontal-axis turbines need to

be turned into the wind. Vertical-axis turbines, on the other hand, need not be aimed into the wind because they rotate perpendicularly to the wind direction. The Darreus, or "eggbeater" wind turbine, is the most common example of a vertical-axis wind turbine.

The maximum power coefficient, or efficiency, is the ratio of power extracted by the rotor to the power available in the wind impinging on the turbine's swept area. Of the wind turbines sampled in a 1986 survey, turbine efficiencies ranged from 26 to 50 percent (EPRI, 1987c).

In general, larger numbers of sub-megawatt generating wind turbines than mega-watt scale turbines have been installed. (EPRI, 1985b) Installation of the smaller units appears to be more flexible and adaptable in the wind fields for electricity generation. Wind power units must serve as intermittent or peaking units.

<u>Potential Applications</u>: Wind fields located in San Gorgonio and Tehachapi are the two principal areas targeted in Southern California for this technology (EPRI, 1985b). Mean wind speeds in these areas typically exceed 6 mph (EPRI, 1985b). Furthermore, land is available where wind turbines can be sited.

Spot applications of wind power are also possible. Electricity generated by wind turbines can be tied to the utility grid or used directly to power water pumps for both agricultural and rural residential use.

The potential capacity of wind power in Southern California is 3000 MW (EPRI, 1985b). This is due primariliy to the availability of suitable land and the high spinning reserve required to maintain generating capacity.

<u>Environmental Impacts</u>: Wind turbines create little air pollution. The primary impacts of wind turbines are visual, noise, and electromagnetic interference. In many areas in California, complaints have been made about the visual impact of thousands of wind turbines spread throughout wind power fields (EPRI, 1986h). These impacts can be mitigated by working with state and local authorities in siting the wind power fields and improving local relations.

Noise has also been identified as a limiting factor. Mechanical and electrical equipment and airfoils are the primary sources of noise (EPRI, 1986h). Through siting, station design, equipment selection, and use of "quiet" airfoils, much of the noise impact can be minimized.

Electromagnetic interference caused by the rotating blades of the wind turbines can produce interference with television reception. Through siting considerations and analysis of local television broadcast characteristics, much of this impact may be mitigated.

Economic Analysis: Prior to 1985, federal tax credits, in addition to a 25% tax credit in California, helped develop the market for investor-owned wind turibnes (EPRI, 1985b). Even without these tax considerations, electricity generated by the wind is expected to cost between 5.0 cents/kWh to 6.1 cents/kWh (1988 dollars) (CEC, 1987d).

Barriers: The single most limiting factor in developing wind power in Southern California is the availability of suitable land. Based on this consideration, the maximum electricity generating capacity within the Basin from wind turbines is approximately 3,000 MW (EPRI, 1985b).

Spinning reserve is also an influencing factor in developing wind turbine technology in Southern California. Spinning reserve is the reserve capacity needed to meet electrical demand peaks since electricity can only be generated when wind currents are strong. Therefore, reliance on wind as an energy source will require higher spinning reserve to ensure supply reliability.

Legislative Needs: Prior to 1985, federal tax credits, in combination with a 25 percent California tax credit, provided strong financial incentives to site wind turbine technology in California. These large tax credits were crucial to the proliferation of wind turbines by making them cost-effective (EPRI, 1985b).

Legislation is likely to be required to reintroduce tax credits both at the federal and state level to make wind power research and project development more viable to investors.

Research Needs: Although each successive generation of wind turbines exhibits significant improvements over the previous generation, technological improvements will still need be made to make wind power more competitive with conventional technologies. More reliable and efficient wind turbines which produce higher power output with less generating down-time are also needed.

Air foil technology must also be improved to help mitigate the acoustical noise associated with wind turbines. These improvements will substantially increase the acceptability of wind turbine technology.

V.2.2 Load Management Technologies

Introduction

Load management, although it does not generate electricity, has become increasingly important in future energy planning. In addition to many benefits to both customers and utilities, load management can ultimately reduce the need to build as many new power plants as might otherwise be required. There are many load management approaches with specific goals to shape the demand load curve. These usually determine if additional generating capacity is needed (CEC, 1986a). The goals of load management include the following (see Figure V-1):

Load Shifting: Shifting loads from on-peak to off-peak periods;

Peak Clipping: Reducing peak loads through improving efficiency, or direct service curtailment.

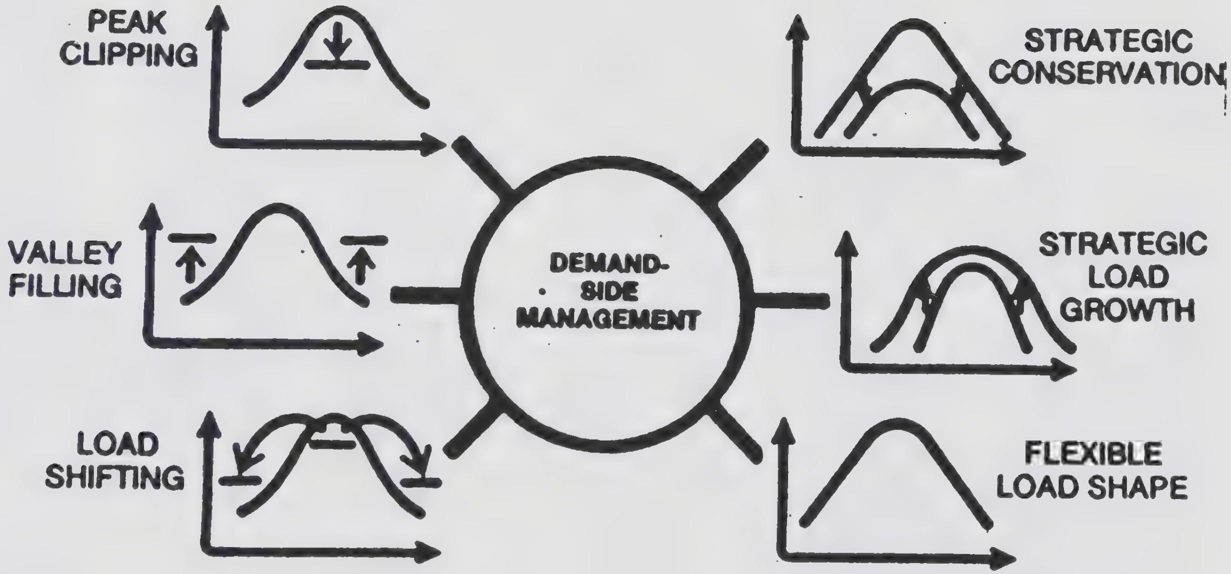
Valley Filling: Increasing off-peak power consumption. Battery charging overnight for electric vehicles and pumped storage fall into this category. This approach is desirable from an air quality point of view only if the power is used to replace air-polluting energy sources.

Strategic Conservation: Reducing overall energy consumption and peak demand.

Strategic Load Growth: Shaping the load curve to minimize the growth during peak hours. This results in overall increase in electricity consumption.

Flexible Load Shape: This not only gives a utility more control over the reliability of its operations, but it can also incorporate the pollution-prevention concept that power generation can be curtailed during unhealthful air quality days.

FIGURE V-1 ILLUSTRATIONS OF LOAD MANAGEMENT GOALS



The following sections discuss specific energy technologies which can achieve one or more the above-mentioned goals. Other non-energy related strategies or measures such as alternate work hours, can also achieve the same goals.

V.2.2.1 Superconductors

Technology Status: The recent dramatic laboratory breakthroughs on superconductors provide a new look at future power generation, electricity transmission and storage. A superconducting generator, although it might only increase energy conversion efficiency by 0.5 to 1 percent over a conventional generator (about 98 percent), does have much greater current-carrying capacity. Due to its high magnetic flux levels, a superconducting generator may potentially be able to reduce the reserve margins. There have been a few small experimental superconducting generators constructed to explore technical problems with such applications. A large scale generator was once planned, but was dropped due to sluggish market trends in the power industry (Douglas, 1987).

Superconducting underground power transmission lines offer several advantages over conventional transmission lines. These include: virtually no transmission loss, high current-carrying capacity, and no right-of-way or esthetic issues comparable to overhead transmission lines. Studies on superconducting power transmission systems date to 1971 at the Brookhaven National Laboratory. In 1982, a 138-KV, 1000-megavoltamphere prototype transmission line (115-meters long) was constructed and has been tested since then. The superconductor was made of niobium-tin alloy and was cooled by liquid helium. The experiments, although confirming the technical feasibility of this technology, also identify technical issues such as cable joints and cryogenics systems that need to be resolved before commercialization and long distance applications are feasible (Forsyth et al., 1986).

Superconducting magnetic energy storage (SMES) utilizes a magnetic field supported by current flowing in superconducting coils. The system would have little line loss, due to no electrical resistance from superconductors, with an estimated 94 percent energy efficiency (Luongo et al., 1987). The conceptual design for a 5000 MWh/1000MW plant (1000 MW in size with a 5-hour charging capacity) was completed in 1980. The coil configuration was subsequently improved by a Department of Energy (DOE) funded program (Loyd, et al., 1986a; Loyd, et al., 1986b; Loyd, et al., 1987; Luongo, et al., 1987). The current version of the SMES system features large scale utility applications with a projected plant life of 30 to 50 years. The stored energy can be discharged over a 5-hour period or all at once.

Based on current progress, the SMES is expected to be ready for utility commitment by the year 2000 (Luongo, et al., 1987). A recently contracted study by the Defense Nuclear Agency to develope the SMES Engineering Test Model to power ground-based lasers and other devices will bring this technology a step closer to commercialization (Bechtel, 1987).

<u>Potential Applications</u>: The attraction of superconductivity to the utilities is its low electric resistance, with virtually no loss in storing and carrying electric energy. Superconducting transmission can allow large blocks of power to be imported from out-of-basin power plants without transmission losses. Large scale utility energy storage can allow all facilities to operate at base-load levels and use the stored off-peak power to meet peak demands. This will have a great impact on electricity costs. Such applications could potentially level the peaking capacity by more than 50 percent, reducing significantly the need for new power generating units.

<u>Environmental Impacts</u>: From an air quality standpoint, superconducting energy technologies can increase power output, reduce power losses due to line transmission, and provide stored off-peak energy to meet the peak demand. As a result, natural resources can be conserved for other beneficial uses. A direct air quality benefit would be the decreasing need to run peaking units which often coincides with the worst air quality conditions. Potential biological effects due to high voltage magnetic fields have been a concern regarding overhead transmission lines. The same effects might exist from using superconductors, which create high voltage magnetic fields. Potential health hazards at the workplace, as well as for the public along the underground transmission lines, warrant further study.

<u>Economic Analysis</u>: The design of a superconducting generator is far more complicated than a conventional generator. Therefore, the superconducting generator is theorectically more expensive. However, because of its high current-carrying capacity, a superconducting generator can be half the size of a conventional generator. Potential costs of superconducting equipment over its lifetime could be competitive with conventional equipment due to manufacturing and transportation costs and better system performance. The discovery of higher temperature superconductors (i.e., liquid nitrogen temperatures instead of liquid helium) would probably have minor economic impacts on overall generator costs, since the cryogenics system represents only a small fraction of the total costs (Douglas, 1987).

The costs of superconducting transmission lines largely depend on the superconducting materials, cable fabrication, and the cryogenics system. The research work at Electric Power Research Institute (EPRI) is aimed at making superconducting underground transmission costs-competitive with conventional lines in the range of 1000 megavolt-amperes for large blocks of power transmission, and in the 20 to 30-mile range for alternating current (AC) lines. The new class of higher temperature superconducting materials could significantly reduce the transmission system costs since a large amount of coolant needs to be refrigerated to maintain superconductivity. The cost savings obtained from electricity otherwise lost due to electrical resistance in conventional transmission lines and from being able to purchase lower cost electricity from a distance make this technology economically attractive.

A more detailed cost analysis was performed for superconducting magnetic energy storage (SMES) (Luongo, et al., 1987). The total capital cost of a SMES system consists of power related costs (i.e., power conditioning system, transformers, and switchyard) and energy related costs (i.e., coil materials and coil construction) which have direct impacts on unit storage costs ($/KWh). It is estimated that a system of between 1,000 to 10,000 MW would have a power-related cost of $120 per KW and between $140 to $310 per KWh of energy-related cost. The annual fixed operation and maintenance costs are $1.0 per KW and $0.33 per KWh. (1985 $). The costs of a SMES system are lower than other energy storage technologies, such as lead-acid batteries, compressed air energy storage, and pumped hydro (Loyd, et at., 1987). Substantial savings can be recovered by utilities by the use of advanced energy storage technology, since cheaper off-peak electricity can be generated or purchased and then used during on-peak hours.

<u>Barriers</u>: The current version of superconducting niobium-based products cooled by liquid helium is very costly. The recent discovery of ceramic superconductivity has provided hope for significantly cheaper superconducting technologies. However, the material's brittleness and current-carrying capacity are questioned by some experts for practical applications (Heppenheimer, 1988). More research at the laboratory scale is necessary to identify superior superconducting materials. In addition to many unresolved and unconfirmed technical issues with even niobium, the lack of significant power growth projected for the next 20 years restricts utilities from making firm commitments to the development of utility superconducting applications.

<u>Legislative Needs</u>: Research and development of superconductors and superconducting materials is very active

in the private sector and in research institutes. The Department of Energy has funded programs to study new superconducting materials, transmission cable systems, and generators (Harrer, et al., 1986). It appears that no specific legislation is presently needed.

Research Needs: Additional research at all governmental levels and the private sector is needed to realize any superconducting commercial applications, including identification of new superconducting materials approaching ambient temperatures, materials fabrication, conceptual design, detailed design, model testing, and full scale demonstration.

V.2.2.2 Solar Heating and Cooling

Technology Status: Solar systems have been used for residential, commercial, and industrial water and space heating. Stationary fixed flat plate collectors and vacuum tubes absorb the solar radiation and transfer the energy to heat water or air. These devices are used most frequently for thermal systems requiring temperatures less than 212^{o}F. Unlike other collection systems, flat plate collectors have the advantage of being able to absorb both beam and diffuse radiation. Therefore, they can continue to function when beam radiation is cut off by clouds.

Solar heat can also be used to produce cool air by vapor absorption (vapor cycle refrigerator) units which are powered by solar energy (Krenz, 1980). Such mechanical devices are commercially available for use with flat plate collectors. The cooling efficiency, defined as the ratio of heat removed from cool space to external heat input (i.e., solar energy), is about 70 percent (Twidell, et al., 1986). In general, solar heating or cooling systems perform better when they are incorporated into the design of new construction. Although retrofitting is feasible, the system performance is often suboptimal due to physical constraints.

Potential Applications: Southern California Edison has encouraged both residential and commercial solar demonstration projects. In Pomona, an automotive center was equipped with solar panels to provide hot water (Mark, 1984). Various residential systems located throughout Edision's service region are also being monitored for performance.

Industries which are most suitable for solar process heating are shown by Standard Industrial Code in Table V-1.

TABLE V-1
MOST SUITABLE INDUSTRIES FOR SOLAR PROCESS HEATING

2-Digit SIC Code	Industry
34	Metal Products Mfg. (hardware, stampings, plating, wire)
20	Food Processing (meat, milk, jams, canned fruits and vegetables, feeds, candy, fats)
37	Transportation Equipment (autos, aircraft, and parts)
35	Machinery Manufacturing (machine tols, farm machines)
33	Metals, Basic (foundries, sheet, bar)
28	Chemicals (includes pharmiceuticals and cosmetics)
36	Electrical Components (switchgear, telephones)
30	Rubber and Plastic Products
32	Concrete Products
38	Instrument Manufacturing
26	Paper and Allied Products

Source: CEC, 1978; Williams, 1980.

<u>Environmental Impacts</u>: See Section V.2.1.3.

<u>Economic Analysis</u>: Private investment in solar water and space heating systems was encouraged through energy tax credits available at both the federal and state level. Although residential credits ended in 1985, commercial tax credits are available through the end of 1988. In the absence of tax credits, the costs of various flat plate

collectors are estimated up to $530 per meter square (1988 $) (Twidell, et al., 1986).

Barriers: Solar heating and cooling systems have not always attained the level of performance claimed by manufacturers. Substantial improvements in system efficiency and reliability are required to regain consumers' confidence in solar products. This is especially critical when tax credits no longer exist. Sufficient consumer information on the performance and limitations of solar systems is also important to help consumers evaluate the systems and to gain market acceptance.

Legislative Needs: See Section V.2.1.3.

Research Needs: See Section V.2.1.3.

V.2.2.3 Thermal Energy Storage

Technology Status: Storing thermal energy is an emerging technique to decrease peak power demand by cooling or heating a storage medium during off-peak hours and releasing the thermal energy during peak periods. The most commonly used media for commercial applications of cool storage are chilled water and ice. Researchers have also investigated various storage media such as aqueous-aqueous, solid-vapor, and solid-solid materials to react thermochemically to provide the desired temperature range for cooling or heating (Stiel, 1987; Christensen, et al., 1986; Rockenfeller, et al., 1986).

Heat pump systems have also been integrated with thermal energy storage systems to provide space heating, air conditioning, and water heating for residential and light commercial applications. It is estimated that 4.5 to 5 kw of peak hour demand per household (based on a home of 2,000 square feet) can be avoided during the summer using this type of integrated system (Phenix, 1987).

Potential Applications: Thermal energy storage is very useful in residences, commercial buildings, and college campuses. Over the past several years, several hundred thermal energy storage systems have been installed due to direct financial incentives from utlities, high demand charges, or application of time-of-use rates to discourage peak power usage (Wendland, et al., 1985). Space cooling is the largest single contributor to summer utility energy peaks, representing one-third of commercial energy use

during the Basin's worst air quality period (Rabl, 1987). Reducing peak demand could decrease the need for new power generating facilities. Thermal energy storage can be used to partially or completely eliminate energy consumption for certain uses during peak hours, depending on the availability of storage media and space.

Environmental Impacts: No emissions are expected. The potential for health and safety concerns exists if toxic chemicals such as ammonia are used as energy storage media.

Economic Analysis: The initial capital cost of thermal storage systems are higher than for conventional heating and cooling units. However, customers can realize significant savings in their utility bills because of the lower operating costs. In addition, many electric utilities offer financial incentives to install these storage systems.

Barriers: Currently available equipment may not be entirely suitable for making ice, the preferred cool storage medium in retrofit systems. Availability of space to locate storage areas in highrise buildings may also be a problem.

Legislative Needs: New constructions should be encouraged to include these systems as part of original heating/cooling systems.

Research Needs: Improvements are needed in subsystem optimization (i.e., refrigeration equipment, storage tanks, and air distribution) and in properly integrating the subsystem. Improved retrofit technologies are also needed. Further research into both larger and small scale residential and commercial applications is necessary.

V.2.2.4 Energy Conservation

Technical Status: There are several energy conservation programs being implemented in California through the California Energy Commission (CEC), including:

> **Mandatory Programs**: Establishment of energy efficient business and residential building standards, appliance standards, and utility load management standards;

CHAPTER VI

STRATEGIC PLANS

Introduction

Based on the information discussed in the previous chapters, three strategic energy plans for the South Coast Air Basin are proposed for implementation by 2007. These plans represent three steps of penetration in various sectors:

> **Plan I includes full electrification in the industrial sector and partial penetration in the transportation sector.** It is the most cost-effective option in terms of energy requirements.
>
> **Plan II, which could be implemented in addition to Plan I, includes full electrification in both the residential and commercial sectors.** Electrification technologies for the residential and commercial sectors are already commercially available.
>
> **Plan III calls for electrifying the entire Basin in all sectors.** This case shows the maximum potential emission reductions that can be secured by full implementation of electrification.

For each plan, the energy required to support the specified level of electrification is identified. A power supply matrix to meet the demand is illustrated for the purpose of demonstrating the likelihood of power availability. In addition, emission reductions and control effectiveness are addressed. The overall economic impact analysis will be discussed separately in Chapter VII. Necessary implementation actions are also identified.

VI.1 STRATEGIC PLAN I

The Plan I envisions one hundred percent electrification of all industrial fuel combustion processes and equipment, and partial transportation sector electrification. The latter is defined as a 20 percent penetration in passenger vehicles, light- and medium-duty trucks; 50 percent penetration in buses; and 90 percent penetration in railroads. These various degrees of penetration represent control measures developed under Tier I and Tier II (Appendices IV-A, IV-G). The electrotechnologies for industrial process conversions are, with a few exceptions, generally commercially available. Technologies for transportation electrification are also available for mass transit systems and railroads. Electric vehicles are nearly

commercialized, awaiting further technical refinements an market incentives. There is a good chance that by 2007, al the technological gaps will be filled.

VI.1.1 Energy Demand

The electric energy demand and peak capacity needed for Pla I is shown in Table VI-1: a total of 32,600 GWh per yea with a daytime peak of 2,060 MW. Another night-time peak o 9,100 MW is anticipated due to electric vehicle batter charging during week nights. Should there be sufficien electricity to meet the night-time needs of electri vehicles, no additional power capacity needs to be added fo the day-time peak capacity of 2,060 MW.

TABLE VI-1
ELECTRIFICATION REQUIREMENTS
FOR STRATEGIC PLAN I

SECTOR	ENERGY(GWH/YR)	CAPACITY(MW)
INDUSTRIAL	4400	1500
TRANSPORTATION	28200	560 /(9100)
TOTAL	32600	2060 /(9100)

VI.1.2 Supply Matrix

A tentative supply matrix is presented in Table VI-2, based on a peak demand of 9,100 MWs. The figures listed in this and succeeding supply matrices should be used for the purpose of discussion only. Since the major electricity demand comes from the transportation sector, and there are control measures proposed in Tier I and Tier II to reduce about 40 percent of vehicle travel in 2007 (see Appendix IV-A), load management in the context of travel conservation is accounted for 40 percent of the total energy demand. Out-of-basin sources will supply 45 to 50 percent of the total demand (about 80 to 90 percent of the remaining need). The in-basin technologies have additional capacity for expansion, if necessary. Among the in-basin technologies, fuel cells are presently at the full scale demonstration stage and utility repowering with advanced combined cycle equipment is being demonstrated with one installation under construction, with commercial operation expected in 1989 (see Chapter V). The rest of the technologies are currently commercialized. Therefore, it appears reasonable to expect that the power required for Plan I can be obtained in the next 20 years.

VI.1.3 Emission Reductions

The potential emission reductions from the source categories identified in Plan I are documented in Table VI-3. As indicated in Table VI-2, repowering and landfill gas combined cycle are the only two gas-fueled power generating technologies expected to be used in the Basin by 2007. However, these two technologies, as addressed in Section V.1.1.1, do not consume more fuel than is currently being used. The extra electricity generated from advanced combined cycle plants is a result of lower system heat rates. In the case of landfill gas units, extra generation is due to waste heat recovery. Furthermore, the utility combined cycle units would probably still serve primarily as peaking units, since the 460 to 910 MW specified in Table VI-2 are well within reserve margin levels (18 percent of the total in Table VI-1). As a result, increases in power plant emissions are not likely. Full credits listed in Table VI-3 can be claimed.

TABLE VI-2
POTENTIAL POWER SUPPLY MATRIX
FOR
STRATEGIC PLAN I

SOURCE	% OF SUPPLY	EQUIVALENT CAPACITY (MWS)
OUT-OF-BASIN	45~ 50	4190~ 4640
IN-BASIN		
REPOWERING	5~ 10	460~ 910
FUEL CELL	2	180
LANDFILL GAS	1	90
SOLAR & WIND	1	90
LOAD MANAGEME	40	3640

TABLE VI-3
EMISSION REDUCTIONS
FOR
STRATEGIC PLAN I

SECTOR	POLLUTANT (TONS/DAY)				
	ROG	NOx	CO	SOx	PM
INDUSTRIAL	16.8	105.4	66.1	15.7	7.5
TRANSPORTATION	62.7	109.3	727.5	9.8	20.4
TOTAL	79.5	214.7	793.6	25.5	27.9

VI.1.4 Control Effectiveness

Control effectiveness is defined as the MWs needed for every ton of pollutant removed. Using capacity (i.e., MW) as an indicator is considered more appropriate than measuring actual energy (GWh) consumption for the purpose of assessing resource availability. Capacity determines how many new power plants at what size need to be built; therefore, capacity is a more important index for resource planning use. Energy consumption reflects the actual usage of the power plants being built and is more directly related to consumer energy costs.

Table VI-4 presents control effectiveness data for various pollutants by sectors, as well as the overall average for Plan I. NO_x and ROG are the two primary pollutants of concern since they contribute to the formation of ozone in the Basin. NO_x is a major contributor to fine particulates as well.

VI.1.5 Implementation Actions

In order to facilitate implementation of Plan I, the following actions are recommended:

(1) Initiation of a detailed and systematic evaluation including new and retrofit technical feasibility, energy consumption, and cost, on industrial electrotechnologies. This analysis will be on a process-by-process and/or equipment-by-equipment basis. Upon completion of the study for various source categories (e.g., oil production, petroleum refinery), appropriate regulatory actions can be taken.

(2) Introduction of electrification as a Best Available Control Technology (BACT) and Best Available Retrofit Control Technology (BARCT) options. Industry can initiate analysis with respect to its specific application and cost, and this allows an industry to plan a long range energy strategy in connection with its air emission compliance plan.

(3) Encouraging the commercialization of non-polluting energy technologies, particularly fuel cell units and electric vehicles through the District's Clean Fuels Program.

(4) Development of clean vehicle emission limits that will expedite commitment to an electrified transportation system.

TABLE VI-4
CONTROL EFFECTIVENESS
FOR
STRATEGIC PLAN I

SECTOR	POLLUTANT (MWS/TON OF EMISSIONS REDUCED)				
	ROG	NOx	CO	SOx	PM
INDUSTRIAL	89	14	23	96	200
TRANSPORTATION	145	83	13	929	446
AVERAGE	115	42	11	357	327

VI.2 STRATEGIC PLAN II

This plan adds full electrification in residential and commercial sectors to Plan I. Plan II will have significantly more electric energy requirements than Plan I, yet yields a relatively small fraction of additional emission reductions. However, the technologies involved in electrifying the residential and commercial sectors are more readily available.

VI.2.1 Energy Demand

As shown in Table VI-5, Plan II requires 109,500 GWh per year with a peak load demand of 21,660 MW. This is about three times the energy and ten times the daytime peak required for Plan I. The night-time peak of 9,100 MW remains the same as Plan I. The day-time peak demand contributed mostly by the residential and commercial sectors assures adequate night-time supply for vehicle battery charging. In fact, if technology permits, Plan II can accept a more than 40 percent penetration in passenger vehicles and light-and medium-trucks without increasing the demand for additional power capacity.

VI.2.2 Supply Matrix

Based upon a peak demand of 21,660 MWs, the potential energy supply matrix for Plan II is shown in Table VI-6. As can be seen, the percentage of supply from load management category has accouted for 50 percent of the total capacity needs, because of the proposed Tier I controls on residential water heaters (see Appendix IV-A) and other energy conservation potential in the residential and commercial sectors (e.g., solar energy, thermal energy storage, heat pumps). Out-of-basin sources will continue to meet the remaining 80 to 90 percent of peak capacity. Plan II is considered feasible, since the in-basin energy technologies have potential capacities greater than those indicated in Table VI-2 (see Chapter V). In fact, there are additional capacities in the areas of landfill gas, combined cycle, and utility repowering with advanced combined cycles that can be brought on-line if sufficient out-of-basin supply is not located.

TABLE VI-5
ELECTRICIFICATION REQUIREMENTS
FOR
STRATEGIC PLAN II

SECTOR	ENERGY (GWH/YR)	CAPACITY (MW)
INDUSTRY	4400	1500
TRANSPORTATION	28200	560 /(9100)
RESIDENTIAL(a)	39500	9900
COMMERCIAL(a)	37400	9700
TOTAL	109500	21660 /(9100)

(a) Averaged values are used as derived from Table IV-3.

TABLE VI-6
POTENTIAL POWER SUPPLY MATRIX
FOR
STRATEGIC PLAN II

SOURCE	% OF SUPPLY	EQUIVALENT CAPACITY (MW)
OUT-OF-BASIN	35-40	7580-8670
IN-BASIN		
REPOWERING	5-10	1080-2170
FUEL CELL	2	430
LANDFILL GAS	1	220
SOLAR & WIND	2	430
LOAD MANAGEME	50	10830

VI.2.3 Emission Reductions

The potential emission reductions by Plan II from various source categories are summarized in Table VI-7. As can be seen, emissions from residential and commercial sectors are relatively small compared with the other two sectors. For the same rationale discussed in Section VI.1.3, no increase in power plant emissions is expected.

VI.2.4 Control Effectiveness

The control effectiveness for Plan II, expressed in megawatts per ton of pollutant removed, is presented in Table VI-8. As indicated in Table VI-8, the residential and commercial sectors would require significantly more power than the industrial and transportation sectors to remove a ton of NOx. The overall average control effectiveness of Plan II is about two times greater than that of Plan I.

VI.2.5 Implementation Actions

In addition to the activities identified in Section VI.1.5, the actions required to electrify the residential and commercial sectors, as specified in Plan II, emphasize load management to reduce energy demand and/or shift peak load. They are:

(1) Coordinating with the California Energy Commission to develop more stringent residential and commercial building codes for new and existing construction to result in greater energy conservation;

(2) Facilitating the development and commercialization of energy technologies which will conserve energy used in space and water heating (e.g., integrated heat pump system and solar energy), or will minimize peak-hour energy consumption (e.g., thermal energy storage and battery energy storage);

(3) Participating in utility load management strategy formulation coordinated by the California Energy Commission, particularly on time-of-use and real-time pricing measures to ensure air quality elements are considered. The main purpose would be to minimize electricity generation during poor air quality seasons by discouraging consumer use of electricity in those periods.

TABLE VI-7
EMISSION REDUCTIONS
FOR
STRATEGIC PLAN II

SECTOR	POLLUTANT (TONS/DAY)				
	ROG	NOx	CO	SOx	PM
INDUSTRIAL	16.8	105.4	66.1	15.7	7.5
TRANSPORTATION	62.7	109.3	727.5	9.8	20.4
RESIDENTIAL	2.0	32.4	19.1	1.1	2.8
COMMERCIAL	0.8	19.9	5.4	0.3	1.0
TOTAL	82.3	267.0	818.1	26.9	31.7

TABLE VI-8
CONTROL EFFECTIVENESS
FOR
STRATEGIC PLAN II

SECTOR	POLLUTANT (MWS/TON OF EMISSIONS REDUCED)				
	ROG	NOx	CO	SOx	PM
INDUSTRIAL	89	14	23	96	200
TRANSPORTATION	145	83	13	929	446
RESIDENCIAL	4950	306	518	9000	3536
COMMERCIAL	12125	487	1796	32333	9700
AVERAGE	263	81	26	805	683

VI.3 STRATEGIC PLAN III

Plan III will call for one hundred percent basin-wide electrification. As a result, this plan requires major technological breakthroughs in electric vehicles, power transmission or storage technologies (e.g., superconductors). In addition, Plan III also requires massive investments in infrastructure and significant changes in life style. It should be noted that Plan III may or may not be necessary to achieve attainment status when integrated with all other control measures. Nonetheless, it provides an upper bound to the electrification strategy in terms of the total emission reductions that can be achieved and their associated effects.

VI.3.1 <u>Energy Demand</u>

The total energy demand for Plan III is shown in Table VI-9. The additional energy required beyond Plan II is attributed to transportation sector electrification. As can be seen, energy consumption is about doubled when compared with Plan II. The day-time capacity needed remains about the same, and the night-time peak increases by approximately five times. This is mainly because the energy used for electric vehicles is still assumed to be generated during the night and not add to the day-time peak. In Plan III, the night-time peak is about twice as much as the day-time peak. It should be noted that if electric vehicles were to exceed 20 percent penetration by 2007, there would have to be major technical breakthroughs. Energy efficiency (kw/mile), in particular, is expected to be lower than what exists today. In addition, several control measures proposed in Tier I and Tier II are directed at reducing vehicle travel. Once implemented, these measures will further lower the total energy consumption and the night-time peak.

VI.3.2 <u>Supply Matrix</u>

A potential energy matrix to support Plan III is presented in Table VI-10, based on a peak demand of 45,400 MWs. A different approach is taken for Plan III than for Plans I and II. As discussed earlier, after considering the load management capacity Plans I and II maximize out-of-basin supply, with in-basin energy technologies to meet the rest of the demand. Plan III first emphasizes load management potential and stretches the in-basin energy generation resources to their expected maximum capacities and then relies on the out-of-basin resources pick up the remaining demand. As a result, the out-of-basin power supply for Plan III is about half of that for Plan II. Again, this is for the purpose of demonstrating the potential maximum in-basin

TABLE VI-9
ELECTRICIFICATION REQUIREMENTS
FOR
STRATEGIC PLAN III

SECTOR	ENERGY(GWH/YR)	CAPACITY(MW)
INDUSTRY	4400	1500
TRANSPORTATION	136250	580 /(45400)
RESIDENTIAL	39500	9900
COMMERCIAL	37400	9700
TOTAL	217550	21680 /(45400)

TABLE VI-10
POTENTIAL POWER SUPPLY MATRIX
FOR
STRATEGIC PLAN III

SOURCE	% OF SUPPLY	EQUIVALENT CAPACITY (MW)
OUT-OF-BASIN	16-22	6600-9800
IN-BASIN		
REPOWERING	11-13	5000-6000
FUEL CELL	2-4	1000-2000
LANDFILL GAS	NEIL	300-500
SOLAR & WIND	5-7	2000-3000
LOAD MANAGEME	60	27300

power capacity. Another rationale for taking this approach is that if Plan III were to be selected, then non-polluting energy technologies such as fuel cell power plants and superconducting magnetic energy storage technologies must be fairly mature. If so, there is no air quality reason to restrict in-basin power supply use if those technologies are utilized. Siting a power plant would then become an economic and local land use issue rather than an air quality concern.

VI.3.3 Emission Reductions

The potential emission reductions due to implementation of Plan III are shown in Table VII-11. No emission trade-offs between electrified processes and power generating facilities are assumed. Because the 5000 to 6000 MWs of utility repowering capacity are within the capacity required by the reserve margin, they are expected to be generated by the peaking units. Therefore, significantly prolonged hours of operation of existing in-basin utility peaking units are not anticipated.

VI.3.4 Control Effectiveness

The control effectiveness for Plan III is provided in Table VI-12. In the transportation sector, the control effectiveness is worse than Plan II's, because the emission reductions contributed by electric vehicles cannot outweigh the additional power required. Plan III has an overall better control effectiveness for ROG, CO, and PM than Plan II, since Plan III's capacity demand is dominated by night-time peak, whereas Plan II's is by daytime peak.

VI.3.5 Implementation Actions

Plan III cannot be implemented without taking the actions listed for Plan I and Plan II, and should be phased in by taking Plan I and Plan II as interim steps. Further development of electric vehicles is extremely critical. Plan III cannot be fully implemented until the operating performance of electric vehicles is improved. Description of cuurent status on electric vehicles is contained in Section IV.4 of this report and Appendix IV-G of the 1988 AQMP Revision. Another important implementation action for Plan III is to develop an emergency plan in case of electricity shortage or blackout. For example, standby equipment such as electric generators burning clean fuels (e.g., methanol), needs to be made available to sustain activities essential to life and safety.

TABLE VI-11
EMISSION REDUCTIONS
FOR
STRATEGIC PLAN III

SECTOR	POLLUTANT (TONS/DAY)				
	ROG	NOx	CO	SOx	PM
INDUSTRIAL	16.8	105.4	66.1	15.7	7.5
TRANSPORTATION	272.0	380.8	3555.8	31.9	90.5
RESIDENTIAL	2.0	32.4	19.1	1.1	2.8
COMMERCIAL	0.8	19.9	5.4	0.3	1.0
TOTAL	291.6	538.5	3646.4	49.0	101.8

TABLE VI-12
CONTROL EFFECTIVENESS
FOR
STRATEGIC PLAN III

SECTOR	POLLUTANT (MWS/TON OF EMISSIONS REDUCED)				
	ROG	NOx	CO	SOx	PM
INDUSTRIAL	89	14	23	96	200
TRANSPORTATION	167	119	13	1423	502
RESIDENTIAL	4950	306	518	9000	3536
COMMERCIAL	12125	487	1796	32333	9700
AVERAGE	156	84	12	927	446

CHAPTER VII

ECONOMIC IMPACTS

Introduction

This chapter addresses the economic impacts of substituting electricity for fossil fuels in the residential, commercial, industrial, and transportation sectors of the South Coast Air Basin. Three plans or scenarios are proposed to achieve partial conversion to electricity.

Plan I requires full electrification in the industrial sector, and partial penetration in the transportation sector. Plan II calls for 100% electrification of residential, commercial, and industrial fuel combustion processes and equipment; 20% penetration in passenger vehicles, light- and medium-duty trucks, and highways; 50% penetration in buses; and 90% in railroads. Plan III entails 100% electrification of residential, commercial, industrial, and transportation activities.

Since at this time it is not known which alternative will be selected, only the economic cost of Plan II is evaluated in this chapter. Plan I excludes the residential and commercial sectors from electrification; thus, it is less comprehensive than Plan II, and its economic costs would be lower. Plan III, on the other hand, is the most comprehensive option, and it would entail higher economic costs than plan II.

The chapter is organized into five major sections, each addressing economic impacts of Plan II on various sectors. The first section analyzes the effect upon energy producers, particularly the petroleum and natural gas industries, which would be highly impacted by the proposed policy. Revenue losses and gains are quantified in this section, and energy costs of implementing Plan II are estimated.

Section VII.2 discusses the impacts upon industrial, commercial, residential, and transportation sectors of the Basin. Section VII.3 reviews the electrification effects upon manufacturers of equipment. A theoretical discussion of the aggregate economic impacts upon the Basin is included in Section VII.4. Conclusions are presented in Section VII.5.

Although this chapter emphasizes the cost side of Plan II, improvements in air quality would indicate that the economic benefits stemming from the use of nonpolluting fuels are rather large. Substitution of electricity and nonconventional energy technologies (e.g., solar and wind power) for fossil fuels could bring about a substantial reduction of air pollution in the Basin. As a result, emission fees currently levied on some industrial processes could decrease or might no longer be required.

Curtailing the consumption of petroleum products and natural gas would help reduce Basin dependency on energy resources whose future remains uncertain. Since a larger share of oil reserves is located in the Middle East, particularly in the Persian Gulf (CEC, 1987e), minimizing dependence upon petroleum-based fuels would make the local economy less vulnerable to oil interruptions and shortages.

Although the future of natural gas is less susceptible to international political manipulation, the California Energy Commission anticipates that by the year 2000, the Basin will have to turn to other states to meet as much as 84% of its total demand (CEC, 1987e). Further, since the existing pipeline capacity seems inadequate to transport the required gas supplies from other areas (CEC, 1987e), the system would have to undergo significant expansion to accommodate the economic growth projected in the Basin.

VII.1 IMPACT ON ENERGY PRODUCERS

In this section, the economic impact of using electricity is evaluated and quantified in terms of revenue losses to petroleum and natural gas producers, and revenue gains to the power industry.

VII.1.1 Assumptions and Limitations

As electricity and other power sources replace fuel combustion in the residential, commercial, industrial, and transportation sectors, demand for oil and natural gas will fall, while demand for electricity will rise. These market changes would result in revenue losses for petroleum and natural gas suppliers and in sale increases for power generating companies. The latter category is defined to include electric utilities and cogenerators.

All monetary gains and losses experienced by energy producers were calculated for 1987, and they exclude important considerations which could augment or diminish the long-run economic impacts of Plan II. Factors not considered include: energy price increases; population and employment growth; advances in production and engineering technologies; new energy discoveries; changes in personal income and lifestyles; and geopolitical factors. Incorporating all these variables into the analysis would make prediction exceedingly difficult.

Long-run predictions have always been far less submissive to economic analysis, and economic assumptions generally become more and more unrealistic the further they are extended into the future. As used in this report, the term "long-run" refers to a period of at least 20 years. Although nothing remains constant

in the long run, the calculation of revenues and losses provides tentative estimates of the economic impacts stemming from the displacement of burning fuels. Thus, the results presented in the following sections should be interpreted with caution and viewed strictly as very rough approximations of market effects.

VII.1.2 Petroleum Industry

Under Plan II, electricity and nonconventional energy sources would replace oil in industrial, commercial, and transportation applications. A 100% substitution of affected petroleum products was not assumed in the calculations because some oil reserves are always needed to run backup equipment in case of emergency. As a result, sales of distillate and residual fuels were assumed to decline by as much as 90%. Distillate fuels include grade oil numbers 1, 2, and 4 used primarily for space heating, occasionally as diesel fuel, and in electric power generation.

Residual fuels encompass grade oil numbers 5 and 6 employed in the production of electric power, larger furnaces in commercial buildings, and factories. Since electric vehicles are expected to substitute about 20% of gasoline-fueled light-and medium-duty vehicles, sales of motor gasoline in the transportation sector were presumed to decline by 20% as well. No adjustments were made for penetration in buses and railroads because their use of fuel is rather small relative to the consumption of motor gasoline by automobiles and small and medium size trucks. Lack of adequate data prevents making adjustments for highway electrification as well. Since the Basin's residential sector uses little or no oil, it is excluded from the analysis.

Table VII-1 shows estimates of various petroleum product expenditures, by type, for the state and the Basin, and expected market losses for year 1987. Information from the California Energy Commission (CEC, 1987e) was used to obtain 1987 estimates of the state's demand for petroleum-based fuels. To compute state expenditures, fuel demand expressed in Btu's were multiplied by 1987 price projections published in the appendices of Fuels Report (CEC, 1987e). The Basin's proportion of state population was used to determine its share of total petroleum product expenditures by the state. The method used to arrive at these calculations is fully described in the Technical Appendix to this chapter.

TABLE VII-1
ESTIMATES OF POTENTIAL MARKET LOSSES:
PETROLEUM INDUSTRY

	Calif. Energy Demand[1]: 1987 (in trillion Btu's)	Avg. Price[2] Per Million Btu's	Calif. Energy Expen-ditures: 1987 (in millions)	SCAB Energy Expen-ditures: 1987 (in millions)	Expected Market Loss	Potential 1987 Losses (in millions
SECTOR						
Electric Utilities						
Distillate Fuel	2.0	$3.91	$ 7.8	$3.6	90%	$ 3.2
Commercial						
Motor Gasoline	8.0	$4.97	39.8	18.3		
Distillate Fuel	14.0	5.08	71.1	32.7	90%	29.4
Residual fuel	24.0	3.30	79.2	36.4	90%	32.8
	46.0		190.1	87.4		62.2
Industrial						
Motor Gasoline	8.0	4.97	39.8	18.3		
Distillate Fuel	110.0	3.91	430.1	197.8	90%	178.0
Residual fuel	54.0	3.30	178.2	82.0	90%	73.8
Other Petroleum Products[3]	726.0	3.09	2,243.3	1,031.9		
	898.0		2,891.4	1,330.0		251.8
Transportation						
Motor Gasoline[4]	1,489.0	$ 7.98	11,882.2	5,465.8	20%	1,093.2
Aviation Fuel	472.0	4.33	2,043.8	940.1		
Distillate Fuel	444.0	5.08	2,255.5	1,037.5		
Residual Fuel	412.0	3.30	1,359.6	625.4		
	2,817.0		17,541.1	8,068.8		$1,093.2
Total	3,763.0		$20,630.4	$9,489.8		$1,410.4

1. CEC. 1987. Fuels Report (Appendices), P. A-4.
2. CEC. 1987. Fuels Report (Appendices), Table E-6; Telephone conversation with Jim Page, CEC, March 29, 1988.
3. Include Asphalt, coke, and still gas.
4. City average retail price of motor gasoline was used to adjust CEC's estimates. See U.S. Department of Energy. 1988. Monthly Energy Review, Washington, D.C., GPO, October 1987, p. 96.

Based on 1987 estimates, it is anticipated that the petroleum industry could lose about 14.9% of the Basin's oil market or $1,410.4 million per year. The largest loss ($1,093.2 million) would occur in the transportation sector,followed by the industrial ($251.8 million), and commercial ($62.2 million) sectors. The petroleum industry employs about 10,300 workers (U.S. Bureau of the Census, 1985). A fraction of its labor force would be impacted by Plan II.

VII.1.3 Natural Gas Industry

Natural gas is used primarily for space heating in the residential and commercial sectors, and as fuel energy to operate, boilers, furnaces, process heaters, turbines, and kilns in the industrial sector, including electricity and cogeneration plants. Substitution of electricity for natural gas would have a negative impact upon natural gas sales.

Table VII-2 displays yearly sales of natural gas, by sector, to Southern California and the Basin. The 1987 volume of gas sold to end users was obtained from the Southern California Gas Company (1988). These data were converted to dollars by using 1987 average gas prices estimated by the California Energy Commission (1987e). The method to arrive at these figures is explained in the Technical Appendix to this chapter.

As a result of Plan II, the natural gas industry is expected to lose about 68.6% of its 1987 market. This loss could have been as much as $2.3 billion in 1987. Although all market segments would not be equally affected, about 82.2% of sales to residential consumers would be lost. This sector is the largest and it accounts for roughly 49% of industry revenues. Further, a relatively large fraction of the gas industry labor force could be affected if Plan II is implemented. At present, this industry employs about 10,500 workers (Los Angeles Chamber of Commerce, 1988).

VII.1.4 Power Industry

As the residential, commercial, and industrial sectors substitute electricity for fossil fuels, the demand for electricity and alternative power technologies will rise. This factor substitution process will bring about a significant increase in revenues for electricity producers. In addition, as the Basin's power industry expands to accommodate the higher demand, its work force is likely to increase well beyond the current level of about 17,000 employees (Los Angeles Chamber of Commerce, 1988).

TABLE VII-2

POTENTIAL MARKET LOSSES
NATURAL GAS INDUSTRY

Market	Estimated Sales: 1987 (in millions) Southern California	SCAB	Expected Market Share Loss: 1987
Residential	$1,355.7	$1,114.4	82.2
Commercial	966.6	441.9	45.7
Power Industry	336.2	243.6	72.5
Industrial	671.9	484.1	72.0
Total	$3,330.4	$2,284.0	

Sources: Southern California Gas Company. 1988. Gas Sales Volume by Air Basin. Internal Report No. CB874. Los Angeles, January 2, 1988.

California Energy Commission. 1987. Fuels Report (Appendices). Sacramento, California, November 1987, p. C31.

Table VII-3 presents 1987 estimates of additional electric energy required to implement Plan II, and corresponding expenditures for various sectors. These numbers are based on estimates presented in Chapter VI (Table VI-5) of this report. Except for transportation, electricity figures are based on existing levels of fuel combustion applications and the current state of electrotechnologies. For the transportation sector, a 1.4% annual growth factor was used to scale back electricity demand from 2007 to 1987. This factor accounts for the increase in daily person trips expected between 1987 and 2007 (SCAG, 1988).

As shown in Table VII-3, electricity demand expressed in GWH/YR was converted to Btu's. The figures were then transformed into monetary values by using 1987 average electricity prices prevailing in the industrial, residential, and commercial sectors. Since electric vehicle battery recharge is likely to take place during off-peak hours, electricity rates for the transportation sector were calculated at 60% of the industry rate.

For year 1987, adoption of Plan II would have generated about $7,547.5 million in revenues for the power industry. When compared to monetary losses experienced by fossil fuel industries, Plan II calls for additional energy expenditures of approximately $3,853.1 million per year.

Although our analysis assumes constant electricity prices, the California Energy Commission foresees electricity rates rising moderately throughout the 1990s, in spite of the projected electricity surplus (CEC, 1987). A rise in electricity rates would make the economic costs of Plan II even greater, especially for the Basin's residential and commercial sectors.

How fast electricity prices will rise in the future depends to a large extent on several factors:

(1) The rate at which additional power to meet the growing demand is generated.

(2) The rate at which the supply of nonpolluting energy alternatives, such as fuel cells and superconducting power transmission and storage, becomes available.

(3) The conservation practices of the residential and commercial sectors.

(4) Government's disposition to encourage conservation among energy users, and its commitment to stimulate and support the development and commercialization of alternative energy systems.

TABLE VII-3

ESTIMATES OF ADDITIONAL ELECTRIC ENERGY
REQUIRED TO IMPLEMENT PLAN II: 1987

Sector	Electricity Demand SCAB (GWH/YR)	Electricity Demand SCAB (millions of Btu's)	Average Price: 1987 (dollars per million Btu's)	Estimated 1987 Expenditures (in millions)
Industry	4,400	15,013,416	$20.97	$314.8
Transportation	20,143	68,730,736	12.58	864.6
Residential	39,500	134,779,530	25.31	3,411.3
Commercial	37,400	127,614,036	23.17	2,956.8
Total	101,443	346,137,718		7,547.5

Sources: Table VI-5.

SCAG. 1988. <u>A Preliminary Draft of Strategies Toward the Development of the Regional Mobility Plan</u>. Los Angeles, February 1988.

U.S. Department of Energy. 1987. <u>Monthly Energy Review</u>. GPO, October 1987, pp. 96-108.

(5) The rate of technological innovation that could lower production costs in this market.

Thus, it is difficult to ascertain how electricity prices are going to behave in response to an alternative fuels strategy. If electric rates climb rather rapidly, substitute technologies that at present are not economical could become efficient and enter the market by the turn of the century. Higher electricity prices would also stimulate greater production of electricity, as well as wider use of energy-saving options and other substitutes such as solar power and wind energy.

VII.2 IMPACT ON VARIOUS SECTORS

This section describes the economic effects of Plan II upon the industrial, commercial, residential, and transportation sectors. To facilitate the discussion, revenue gains and losses to energy producers have been collapsed and made to conform with the grouping presented in Table VII-4 which shows the energy costs and savings of Plan II. Expenditures on oil and natural gas by electric utilities were included in the industry category. Since these estimates are subject to a wide margin of error, they should be interpreted only qualitatively or used to ascertain the direction rather than the magnitude of the impacts.

It is important to note that although Plan II could lead to additional energy costs, Plan I would have a relatively smaller cost impact upon the Basin.

VII.2.1 Industrial Sector

Data displayed in Table VII-4 suggest that the shift to electricity could possibly lead to energy economies in the industrial sector. There are two plausible explanations that could account for the apparent energy saving. As discussed in previous chapters, the electrotechnologies expected to replace internal combustion processes and equipment are highly efficient in the use of electricity.

Second, most manufacturing processes in the four-county area do not appear to be energy intensive (Table VII-5). Except for petroleum and coal (SIC 29); stone, clay, and glass (SIC 32); and primary metals (SIC 33), expenditures on energy constitute only small fraction of value added by manufacture. Value added includes the dollar value of shipments minus the cost of materials, supplies, containers, and merchandise operations. These three sectors (SIC 29, 32, and 33) represent 6% of all manufacturing employment and 1.4% of total jobs in the Basin (U.S. Bureau of the Census, 1985; California Department of Finance, 1986).

TABLE VII-4

ENERGY IMPACT OF PLAN II: 1987
(IN MILLIONS)

Sector	Gas +	Oil =	Total	Electricity	Potential Costs(+) or Savings (-)
Residential	$ 1,114.4	0	$ 1,114.4	3,411.3	+
Commercial	441.9	62.2	504.1	2,956.8	+
Industrial	727.7	255.0	982.7	314.8	-
Transportation	0.0	1,093.2	1,093.2	864.6	-
	$2,284.0	$1,410.4	3,694.4	$7,547.5	

Sources: Tables VII-1, VII-2, and VII-3.

Note: Potential costs (+) or savings(-) are derived by subtracting total expenditures on gas and oil from electricity expenditures.

TABLE VII-5
ENERGY USE BY INDUSTRY AS A PERCENT OF VALUE ADDED:
LOS ANGELES COUNTY 1981

SIC	Industry	Value Added by Manufacture	Cost of Fuel	Percent
20	Food and kindred products	3,110.6	103.8	3.3
22	Textile mill products	248.9	15.6	6.3
23	Apparel & other textile products	1,742.0	27.5	1.6
24	Lumber and wood products	291.6	7.4	2.5
25	Furniture and fixtures	1,072.3	19.3	1.8
26	Paper and allied products	686.0	57.9	8.4
27	Printing and Publishing	2,422.3	30.9	1.3
28	Chemicals and allied products	1,762.9	101.4	5.7
29	Petroleum & coal products	2,174.8	313.6	14.4
30	Rubber & miscellaneous plastic	997.2	5.4	5.6
31	Leather & leather products	147.5	5.4	3.7
32	Stone, clay, & glass products	779.7	110.0	14.1
33	Primary metal industries	739.5	106.5	14.4
34	Fabricated metal products	2,948.1	106.7	3.6
35	Machinery, except electrical	3,702.4	58.4	1.6
36	Electric & electronic equipment	5,128.3	68.0	1.3
37	Transportation equipment	9,334.0	162.7	1.7
38	Instruments & related products	1,138.8	15.7	1.4
39	Miscellaneous mfg. industries	1,027.9	16.1	1.6
	All industries	39,455.1	1,400.4	3.7

Source: U.S. Bureau of the Census. 1985. Census of Manufactures, 1982. Geographic Area Series. California (MC82-A-5), pp. 36-41; U.S. Bureau of the Census 1983. Census of Manufactures, 1982, Subject Series. Fuels and Electric Energy Consumed Part 2: State and SMSA's by Industry Groups (MC82-S-4), Washington D.C., GPO, pp., 86-137.

According to SCAG (1988), the five most important manufacturing activities in the Basin are electric and electronic equipment (SIC 36); transportation equipment (SIC 37); machinery, except electrical (SIC 35); fabricated metal products (SIC 34); and apparel and other textile products (SIC 23) (SCAG, 1986). Energy expenditures in these industries are practically insignificant, ranging only from 1.3% to 3.6% of total value added. Thus, substitution of electricity for fossil fuels is likely to be of little consequence in these industrial activities, which account for as much as 57% of all manufacturing occupations and 13.7% of total employment in the Basin.

Nevertheless, transferring to electricity or nonpolluting energy would call for changes in industrial installations and production processes. This involves investment expenditures and increased costs to industrial facilities, especially manufacturing. Capital and operating costs for some electrotechnologies are described below:

(1) Microwave Heating
This technology is for heating rubber before molding it into parts or for converting investment castings for precision parts. The process is also used in ceramic slip casting, ceramic firing, and chemical processes, and for heating fluids. The capital cost of equipment ranges between \$2,000 to \$5,000 per kilowatt of installed power. Operating costs are comparable to those of conventional heating methods (CMF, 1987a).

(2) Indirect Resistance Heating
Electric furnaces produce indirect resistance heating used primarily in the metal, ceramics, electronics, and gas industries. Equipment size and operating temperature determine the furnace capital cost. A 2ftx3ftx1.5ft furnace, operating at up to 2,000^{o}F could cost about \$35,000. If size increases to 5ftx6ftx5ft., cost would jump to \$150,000. Operating costs are a function of the energy used and the furnace's operating efficiency (CMF, 1986).

(3) Short Wave Infrared Curing
High-intensity, short-wave infrared curing ovens could replace convection ovens for coating and finishing systems. Limited information on the application of this technology suggests that new coating and curing equipment could sell for about \$450,000. Installation costs are approximately \$1.0 million. Acquisition of this equipment, however, results in significant increases in productivity and substantial reductions in operating costs. These cost savings could possibly make the investment to pay for itself in about three years (CMF, 1987b).

(4) Induction Heating
This electrotechnology could be used for heating prior to metal forming, heat treating, seam welding, and melting. An induction heating and vibratory bowl feeder could cost about \$425,000. A

cooling tower and transformers would increase capital costs substantially. Since significant savings are obtained in energy and manufacturing costs, the investment pay back period could be as short as 1.5 years (CMF, 1987c).

(5) UV Curing

Ultraviolet (UV) curing can be used in many industrial applications. For example: coatings on cans, paper cups, and tubes; for paper, metal, woods, and glass products; in medical and automotive applications; for electronics, graphic art films, and optical fibers; and for applications of semiconductors wafers. Equipment capital cost varies significantly with the type of application. When used for curing of coatings on beer cans, for instance, the cost of a UV system for a two-piece can line running 1,500-1,600 cans per minute ranges between $200,000 and $225,000. This price excludes bottom-cure equipment, but includes the UV lamps, power supply, shield enclosure, transport mechanism, and the cooling and exhaust fans (CMF, 1987d). If used to produce labels, coupons, and tags with durable finishes, equipment cost is about $100,000 when added to a printing press (CMF, 1987e).

In the long run, additional costs resulting from the acquisition of these electrotechnologies might not become a burden, however. Given the time frame considered for conversion to electricity, capital expenditures could be minimized by acquiring new equipment when the old one has been completely depreciated and can be scrapped or when plants are expected to be upgraded. There is always the likelihood, however, that small producers and marginal firms might not have adequate resources to switch to electricity. Some of these plants could be forced to shut down and their lost output would likely be produced by relatively larger and more efficient industrial facilities.

Thus, ruling out significant increases in electricity rates and assuming that the capital cost of electrotechnologies and nonconventional energy options do not outweigh the energy savings from using electricity, the Basin's manufacturing sector is not likely to be significantly impacted by electrification. This is especially true if the transition to alternative fuel sources proceeds gradually and firms are allowed sufficient time to make conversion adjustments when their equipment is obsolete or when plants are scheduled to undergo modernization. At present, many production processes are suitable for solar energy technologies as well (SCAQMD and SCAG, 1985). Nonetheless, industry could fail to recognize the energy cost advantages of installing electrotechnologies, especially if oil and natural gas prices remain relatively low.

VII.2.2 Commercial Sector

Table VII-4 indicates that as far as energy cost is concerned, the commercial sector would be highly impacted if it were to

shift from natural gas to electricity. This energy market segment includes establishments engaged in wholesale and retail trade; finance, insurance and real estate; and private and public services. Running large space and water heaters with natural gas is still cheaper than using electricity. For instance, it would cost approximately 3-4 times more to fuel commercial appliances with electricity than with natural gas (U.S. Department of Energy, 1985).

It is reasonable to expect, however, that as the cost of operating commercial appliances with electricity increases, owners and operators of commercial establishments (e.g., restaurants, hotels, office buildings, and related facilities) would search for alternative technologies which could substitute for the additional power required by electrification. Thermal energy storage, heat pumps, waste heat recovery systems, super-efficient appliances, and solar energy, for example, could become instrumental in helping the commercial sector cope with higher electricity costs included in Plan II.

Regarding the investment expenditures to acquire the new space and water heaters, along with the new electrotechnologies, they could be minimized if made when the old equipment has to be discarded or when commercial facilities are built.

VII.2.3 Residential Sector

Plan II (Table VII-4) would impose a heavy burden upon residential users. Table VII-6 indicates that for a typical Southern California home, average electricity cost for space and water heating, clothes drying, and cooking is about four times the cost of natural gas. Consequently, substitution of electricity for natural gas would increase the average residential utility bill, assuming that electricity rates remain constant. Unless the price of electricity falls, or cheaper nonpolluting energy alternatives become available, consumers would be impacted when shifting to electricity, especially low income groups.

Table VII-7, for example, shows that western households with incomes of less than 75% of the poverty line spend as much as 25% of their income on home energy. Assuming that the relative price of electricity remains constant, its substitution for natural gas would increase the proportion of income devoted to home energy consumption. Under this scenario, low income families would experience a sharp increase in their electric bills, and could end up spending much more than 25% of their income on home energy. The impact would not be as large for middle or upper income families whose energy expenditures constitute a relatively small fraction of their income.

TABLE VII-6

ANNUAL OPERATING COSTS FOR APPLIANCES AND MARKET SHARES

Appliance	Gas	Electric	Gas Share of Appliance
Space heating	$241	$ 576	97%
Water heating	126	335	98%
Clothes drying	31	73	75%
Cooking	64	1,090	82%
	$462	$2,074	

Source: Southern California Gas Company. 1987. Fact Sheet. Los Angeles, Spring 1987.

TABLE VII-7

HOME ENERGY EXPENDITURES AS A PERCENT OF HOUSEHOLD INCOME

Region	Income as a Percent of Poverty Income			
	75% or less	75-125%	125-200%	more than 200%
Northeast	41	16	10	5
North Central	29	14	8	4
South	30	13	8	4
West	25	9	5	3

Source: Wayne L. Hoffman. 1979. The Distribution of Home Energy Expenditures by American Households in 1976- 1977. Working Paper 1197-3. Washington, D.C.: the Urban Institute. (Cited in Raymond J. Struyk. 1984). Home Energ Costs and Housing of the Poor and the Elderly. Energy Costs, Urban Development, and Housing. A. Downs and K. Bradbury (eds.). Washington, D.C.: The Brookings Institution, pp. 35- 76.)

In the long run, however, affected families could in part avoid large increases in electricity costs by reducing their energy consumption through conservation practices (e.g., insulation, weather stripping, caulking, super-efficient appliances, etc.), moving to smaller or more energy efficient units (Struyk, 1984), or relocating to neighborhoods with lower rents or housing prices (Small, 1984).

Although homeowners and landlords would have to retrofit their housing units with electric space and water heaters, or invest in renewable energy technologies, such as solar heating, limited information obtained from a local department store indicates that the price differential between electric and gas appliances is rather small. For example, a 50-gallon electric water heater sells for about $260, compared to $290 for its gas counterpart. Further, the price of a 30-inch electric range ($440) is approximately 9% lower than the price of a comparable equipment fired with natural gas ($480). Although specific estimates are not available at this time, electric appliances, especially home heating, might require relatively higher installation costs (e.g., rewiring and upgrading the level of service) in housing units designed for natural gas usage.

VII.2.4 Transportation Sector

Plan II assumes a 20% electric vehicle penetration for the year 2007. Thus, the cost of using electricity instead of motor gasoline in the transportation sector could possibly lead to savings in fuel costs (Table VII-4). The viability of substituting electric vehicles (EV's) for gasoline-powered automobiles depends upon the successful commercialization of this type of vehicle.

EV's are pollution free. They also have lower maintenance costs, longer life, and run quieter (Scheffler, n.d.). But the California Air Resource Board identifies four possible obstacles to EV commercialization (CARB, 1985). First, EV's appear to have a much shorter driving range (25-33%) than internal combustion vehicles (ICV's). Second, acceleration is still slower for EV's. Third, battery recharging for EV's has to be done more frequently than gasoline refueling. This particular problem is linked to the technological state of battery characteristics such as energy power and life cycle. Current developments in the manufacture of plastic batteries could potentially overcome some of these shortcomings. The new plastic batteries are lighter, more durable, could be recharged faster, and could generate higher power to increase acceleration (CARB, 1985). Finally, and most significantly in terms of economic impacts, the cost of owning and operating an EV appears to be relatively higher. Electric vehicles could become more economically attractive, however, if gasoline prices were to increase significantly and major breakthroughs in battery technology were to occur in the future.

Nevertheless, for certain commercial applications, EV's seem to be quite competitive with ICV's. Table VII-8 summarizes the cost of owning and operating EV's for urban deliveries. The comparison applies to vans used in short delivery trips characterized by frequent stops and limited highway use. Because of the high battery expense, the electric van has relatively higher capital and depreciation costs. Fuel and maintenance outlays are about 50% lower for the EV. Although a gasoline price below $1.15 per gallon introduces a cost disadvantage for the electric van, even at today's gas prices of $0.85 per gallon, the cost of owning and operating the conventional van would be only 7% lower or 37.8 cents per mile.

Thus, if EV market penetration is limited to businesses with large fleet of light or medium-duty vehicles involved in merchandise pick-up and deliveries, and requiring many stops and relatively short trips through congested city areas, Plan II is not likely to have a negative economic impact upon such firms. Further, EV's could be purchased when gasoline vehicles need to be replaced or vehicle fleets are expanded.

Thus, as the market for EV's continues to grow, research to improve system components is likely to intensify, making EVs more reliable and cost effective. Some electric vans, such as the Griffon, are expected to compete with their gasoline-powered counterparts by 1990 (Cohen, 1986).

VII.3 IMPACT ON MANUFACTURERS OF EQUIPMENT

As the Basin moves to electricity, firms involved in the production and distribution of electric equipment and electrotechnologies are likely to experience an increase in demand for their products. Thus, business and employment opportunities would be created in research, manufacturing, marketing, and sales of nonpolluting energy technologies. By the same token, as the modern energy devices push their way through the market, sales of fossil fuel-based equipment and parts would decline.

VII.3.1 Residential and Commercial Appliances

Plan II would stimulate sales of electric space and water heaters, ranges and dryers to be used in residential and commercial applications in the Basin. Although the price of these appliances could increase as demand rises, in the long run, higher prices and increased sales are likely to encourage production and bring down prices.

TABLE VII-8

Comparing Costs for an Urban Delivery Van Application

	Electric Van	Conventional Van
Assumptions		
Van cost	\$19,300[1]	\$12,100
Replacement battery	\$ 4,750	
Fuel Consumption	0.9 kWh/mi	10 mpg
Fuel Cost	5/kWh	\$1.15/gal
Salvage value	20%	15%
Battery salvage value	5%	
Life-Cycle Cost (/mi)		
Depreciation		
Vehicle	13.5	11.7
Battery	10.0[2]	
Cost of capital[3]		
Vehicle	4.4	3.6
Battery	1.4[2]	
Fuel/electricity	4.5	11.5
Maintenance	7.0	14.0
Total cost (/mi)	40.8	40.8

1. Includes battery
2. Includes replacement of the battery after four years.
3. Real cost of capital assumed to be 6%/yr.

Source: Excerpted from Cohen, Jon, 1986. "Fleet Vans Lead the Way," Electric Power Research Institute Journal, July/August 1986, p.28.

Presently, about 45 firms involved in the manufacture, wholesale, distribution, or service of electric appliances (e.g., space and water heaters, heating equipment, furnaces, and ranges) are located in the Basin. The work force in these companies range anywhere from 5 to 500 employees, and together they employ approximately 6,200 persons (Los Angeles Area Chamber of Commerce, 1988).

VII.3.2 Electrotechnologies

Conversion to electricity in the industrial sector would create business opportunities and additional research and development expenditures in the electrotechnology field. At present, the Basin has about 40 firms engaged in the manufacture, distribution, and repair of electric motors and electronic parts. These firms employ over 5,300 workers, and range in size anywhere from 9 to 1,200 employees (Los Angeles Area Chamber of Commerce, 1988).

Investment in the manufacturing and marketing of electricity-based industrial processes, such as direct arc melting, induction melting, plasma processing, and electron beam heating, would also stimulate employment in promotion, research, technical, and personnel development, and in the construction of manufacturing facilities and distribution centers.

As industry shifts to electricity, sales of fuel combustion equipment and installations (e.g., oil-fired or gas-fired turbines and boilers) would fall. This effect, however, could be more than offset by the growth of the electrotechnology industry.

VII.3.3 Power Generating Technologies

Since about 10 to 20 percent of the additional electrical capacity required by Plan II is expected to be produced in the Basin, existing capacity would have to be expanded and new power plants constructed. The growth of the power sector would stimulate employment in research and development, and in construction.

Industrial expansion would also increase sales of electric transmission and distributional equipment needed to produce and import the additional electrical capacity required in the Basin. Thus, industries engaged in the manufacture of electrical transformers, solenoids, coils, and power transmission lines are likely to benefit as the result of Plan II. About 34 of these firms are located in the Basin and employ a labor force of approximately 1,324 workers (Los Angeles Area Chamber of Commerce, 1988). In addition, Plan II is likely to encourage the development and fabrication of electrochemical generators (e.g., fuel cells) and superconductors.

VII.3.4 Renewable Energy Technologies

Adoption of Plan II is likely to encourage the continuous growth and use of renewable energy technologies, especially solar energy. At present, there are about 13 companies involved in the production, distribution, and service of solar equipment in Southern California. These facilities employ a labor force of about 1,000 persons, and nine of them operate in the Basin (Los Angeles Area Chamber of Commerce, 1988).

An important solar energy technology is the photovoltaic cell, a device that transform sunlight into electricity. Stimulated by the 1973 oil crisis, production of photovoltaic cells in the United States has tripled since 1980 (Fogel, 1985). Increased application of this technology is stimulating the supply side of the market, causing the price to decline very rapidly. The cost of a one-watt cell, for example, has dropped from $600 in the 1950's to $10 in 1985. The photovoltaic industry estimates that by 1990, the cost of a cell could be as little as 90 cents (Fogel, 1985). Other promising solar energy options include intermediate- and high-temperature solar collector systems and thermal energy collectors.

Two renewable energy technologies whose growth is likely to be accelerated by the electrification plan are wind power and geothermal energy.

VII.3.5 Electric Vehicles and Parts

Commercialization and use of electric vehicles in the Basin would hasten the development of service infrastructure, such as repair and maintenance service centers, stores to stock and sale special parts and components, and skilled technicians to service and repair these vehicles.

VII.4 AGGREGATE ECONOMIC IMPACTS

In this section the aggregate economic impacts of Plan II are discussed qualitatively. The long-run economic effects of using electricity seem to depend on whether additional supplies of electricity and nonconventional energy forms are largely produced locally or outside the Basin. If they are locally produced, aggregate demand for goods and services could possibly fall. The reasoning behind this conclusion is as follows.

When standardized for heat content, the price of electricity is 4-5 times as high as that of natural gas (U.S. Department of Energy, 1985). As shown in Table VII-4, the additional energy costs of Plan II upon residential and commercial users of electricity seem to exceed the savings conferred upon the industrial and transportation sectors by about $3.9 billion.

Thus, unless additional power requirements are produced at relatively lower prices, or the efficiency of electric equipment increases sufficiently to compensate for the difference in heat content, the total energy bill to run the Basin's economy is likely to rise.

To cope with higher energy costs and higher product and service prices, households would consume less and businesses would postpone investment spending. These actions could possibly slow down economic growth in the Basin. This situation is likely to change if the revenue gains experienced by the power industry are all reinvested in the Basin and personal income increases enough to offset price rises. In this case, economic expansion of the power industry could balance Plan II's negative economic effects upon the fossil fuel, residential, and commercial sectors. Under these circumstances, Plan II would lead to an income redistribution or transfer of wealth among energy producers, households, and businesses.

On the other hand, if additional power requirements are largely imported, there would be no economic expansion to offset the output and revenue losses experienced by the petroleum and natural gas industries or to balance the decline in purchasing power experienced by the residential and commercial sectors. This case is particularly relevant to the Basin because 80-90% of additional power requirements would have to be imported. Consequently, aggregate demand is likely to fall, slowing down the rate of consumption and investment expenditures, and overall economic activity in the Basin. Moreover, local and state tax revenues are likely to decline as well. These adverse economic impacts could be softened if part of the income losses return to the Basin in the form of new capital investments or expenditures on goods and services. Cleaner air, for example, could entice population and employment to locate in the Basin, helping to restore the loss in purchasing power and to stimulate economic recovery.

VII.5 CONCLUSIONS

It is complicated and difficult to determine how the Basin's economy would respond to electrification. There are too many unknowns that cannot be properly identified or anticipated, especially in the long run. Realistically, the question can only be answered on empirical grounds and after Plan II has been implemented for several years. The long-run economic impacts depend upon future economic conditions; the extent to which the additional electricity supply is imported; consumers' and producers' reaction; the future prices of energy alternatives; and technological changes affecting energy needs.

The limited evidence examined in this chapter implies that the high energy cost of Plan II could have a negative impact upon the Basin's economy. Further, the cost of Plan II is likely to fall upon the residential and commercial sectors as much as upon the petroleum and natural gas industries.

TECHNICAL APPENDIX TO CHAPTER VII

Petroleum Industry

To estimate potential market losses to the petroleum industry, the following approach was followed.

The California Energy Commission's 1987 Fuels Report (Appendices) was used to obtain 1987 estimates of the state's demand for petroleum products by sector. Since these data were expressed in Btu's, they were converted to monetary values by using projected 1987 fuel prices, by sector, also reported in Fuels Report. Prices are listed and briefly explained below.

Sector	Petroleum Product Prices (Price per million Btu's)
Electric Utilities:	
Distillate oil	$3.91 Diesel fuel #2 (wholesale)
Commercial	
Motor gasoline	$4.97 Regular unleaded gas (wholesale)
Distillate fuel	$5.08 Diesel fuel #2 (retail)
Residual fuel	$3.30 Residual oil with less than 0.25 sulphur content
Industrial	
Motor gasoline	same as above
Distillate fuel	Diesel fuel #2 (wholesale)
Residual fuel	same as above
Transportation	
Motor gasoline	$7.98 U.S. city average retail price of all types of gasoline
Aviation fuel	$4.33 jet fuel (wholesale)
Distillate fuel	see commercial sector above
Residual fuel	see commercial sector above

Average U.S. city price of gasoline regularly published in Monthly Energy Review was used to compute motor gasoline expenditures in the transportation sector.

To determine petroleum product expenditures in the Basin, state expenditures were adjusted according to the Basin's share of state population, approximately 46%. The amount obtained was $9,489.8 (Table VII-1).

Calculations of potential revenue losses for 1987 were obtained by assuming the following market share declines:

Distillate fuel:	90%
Residual fuel	90%
Motor gasoline	20%

Natural Gas Industry

To compute 1987 market losses for the natural gas industry, the 1987 volume of gas consumed, by sector, in Southern California and SCAB, was obtained from the Southern California Gas Company (1988). The ratio of natural gas consumption by electric utilities and cogenerators to industrial sector sales in the Southern California Gas Company territory was used to estimate sales to electric utilities and cogenerators in the Basin. All the natural gas consumption by cogenerators was assumed in the industrial sector. As computed in Table VII-2, sales of natural gas to industry excludes electric utilities and cogenerators. Since these figures were expressed in thousands of cubic feet, they were converted to British thermal units (Btu's).

To determine the dollar value of gas sold to various sectors, average prices estimated by the California Energy Commission (1987) were used:

Residential sector	$5.24	per million Btu
Commercial sector	5.15	"
Industrial sector	3.76	"
Electric utilities and cogenerating plants	2.76	"

Power Industry

Except for the transportation sector, 1987 estimates of additional electricity demand were used to compute electricity costs. These values were assessed on current levels of fuel combustion applications and existing electrotechnology energy efficiency. (See Chapter II of this report.)

Additional power required was then converted to Btu's.

For the transportation sector, a 1.4% annual growth rate (SCAG, 1988), based upon the increase in daily person trips expected between 1984 and 2007, was used to scale back electricity demand from 2007 to 1987.

The State Energy Price and Expenditure Report: 1970-1982 (U.S. Department of Energy, 1985) was used to obtain average electricity prices, by sector, for California. These values were then adjusted for 1982-1987 changes in electricity rates reported in the Monthly Energy Review (U.S. Department of Energy, 1987).

Electricity rates for the transportation sector were estimated at about 60% of industry rate because electric vehicle batteries are likely to be recharged during off-peak hours, when excess power capacity is available

CHAPTER VIII

CONCLUSIONS AND RECOMMENDATIONS

VIII.1 CONCLUSIONS

Conclusions based on the evaluation presented in the previous chapters of this report, are:

(1) An electrification strategy, in principle, appears to be a valid alternative to conventional air pollution control action. Emission trade-offs between fuel combustion and power generation can be avoided if energy supply from out-of-basin sources and non-polluting technologies can be developed.

(2) Many electrotechnologies are commercially available to substitute for industrial fuel combustion equipment and processes. The preliminary energy demand data show favorable emission control effectiveness, although this is subject to verification by further detailed study. Technical assessments on process-specific applications are also necessary.

(3) Electrification in the transportation sector can provide the greatest emission reduction potential among all sectors studied. However, its feasibility depends largely on the commercialization of electric vehicles, better vehicle performance, substantial public funding commitments to roadway construction or modification, and broad public acceptance of significant change in infrastructure.

(4) Energy consumed for electrifying water and space heating processes in residential and commercial sectors will be significantly greater than for industrial and transportation sector electrification for every ton of air pollutant removed. However, the electric technologies for conversion are readily available so that electrification can be implemented without major technical obstacles. Additionally, the technologies for energy conservation are relatively effective, so that, the overall energy demand can be substantially reduced.

(5) In order to maximize the emission reductions contributed by electrification, the Basin will heavily rely on power supplies from out-of-basin,

if fossil fuel combustion continues to be the main energy source. If technology permits, 80 to 90 percent of the net District power demand after considering all feasible in-basin load management measures (e.g., energy conservation, vehicle travel control) will be imported.

(6) The recent developments in fuel cell power plants, superconducting power technologies, and various load management approaches can significantly change the way electricity is generated and how it is used. Therefore, commercialization of those technologies is critical to the success of the electrification strategy.

(7) The potential emission reductions, using NOx as an index, range from 215 tons per day to 500 tons per day, depending on the extent of electrification.

(8) Although the economic impact of electrification are difficult to unravel empirically, the limited evidence presented in the report suggests that the high energy costs required by electrification could have a negative effect upon the Basin's economy.

VIII.2 RECOMMENDATIONS

Based on findings discussed in Section VIII.1, in order to encourage the affected parties to develop long term plans for their businesses and expedite commercialization of necessary technologies, recommendations to the District Board include:

(1) Establish an electrification task force to (a) perform a detailed technical evaluation of individual electrification technologies; (b) develop and recommend implementation plans in light of several competing control measures currently under development; (c) monitor the progress of strategy implementation to assure that the burden falling upon highly impacted business and individual groups is minimized.

(2) Conduct extended analysis to evaluate fully the economic costs and benefits of replacing fossil fuels with electricity. Further, the policy consequences, especially changes in the Basin's employment, income, and wealth redistribution should be thoroughly analyzed and their magnitude should be quantified as fully as possible.

(3) Investigate the viability of an income redistribution program to compensate the losers. Such a program might be justified on equity grounds, and should be carefully considered.

(4) Participate aggressively in the development of non-polluting energy technologies (i.e., fuel cells, energy storage) and an electrified transportation system (i.e., electric vehicles, highway electrification) through the District Office of Technology Advancement.

(5) Establish a dialogue with the energy policy-making bodies at state and federal levels to obtain technical assistance and consistency in formulating policies. For example, in protecting the electric utilities from unregualted competition, CEC and CPUC should take into account the additional capacity requirements resulting from the electrification strategy; review demand conformance criteria to reflect additional need for electricity; and relax guidelines for demonstration projects as to encourage faster development and commercialization of new energy alternatives.

(6) Encourage the power industry to take the lead in subsidizing the development of new energy technologies, conducting demonstration programs on these new methods, and disseminating information regarding new approaches to economize in the use of electric energy.

(7) Seek Federal and state tax incentives to hasten the development and deployment of alternative energy options such as wind and solar power, fuel cells, and conservation measures.

CHAPTER IX

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